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A

TEXT BOOK

SMITHSONIAN INSTITUTION.

ON

AGRICULTURE.

BY

N. S. DAVIS, M. D.

Mater omnium Artium, est Scientia.

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INTRODUCTION.

It is now universally conceded that no branch of business is susceptible of receiving greater benefit from science, than Agriculture ; and that such benefits may be actually received, it is equally apparent that the subject must be introduced as a regular study in all our common schools and academies ; for although special agricultural schools and model farms may be established here and there, and be productive of much good, yet the common or district schools and the local academical institutions must ever constitute the main reliance of the great mass of the youth of this country for the sum total of their education. Hence we think a legislative committee never uttered a truer sentiment than the following, taken from the report of the Committee on Agricultural Schools in the Legislature of 1847. In reference to the plan recommended by the Committee, the report says: "The plan alluded to is to encourage the study of agriculture in the Normal School, and in the academies and local institutions which

are already established and endowed in all parts of the State. We would *also encourage its study in our best common schools.*"

It is well known that all the older class of scholars in our common schools, and many in the academies, spend a part of each year with their parents in labor on the farms. In this way they might be constantly testing by practice the principles they learn in the schools; or, in the language of the Committee' "The school and the farm by this plan become mutual aids. The principles are acquired in the school, and the scholar becomes ambitious to test them in the fields; from which it would follow that the whole State, with its different soils and climate, becomes one great experimental farm, every intelligent farmer an intelligent experimentalist, every farm a model farm, and every farmer's son a teacher, or, at least, an earnest learner."

What a happy change would this make in the greatest and most important industrial pursuit of man! And that the Committe referred to have recommended the only effectual plan for accomplishing so desirable a result, we think no man, after due reflection, will deny.

But the very first step in advancing the study of agriculture is the adoption of a text-book, suited to the condition of the schools.

To accomplish this object the State Agricultural Society offered a premium for the best work designed for this purpose. It was in answer to this call that the following work was written. But the time allowed by the Society was so short, that when the work was presented for examination, one of the most important chapters was left unfinished and entirely without the appendix. Notwithstanding, the examining committee decided the work to be the best presented, and awarded a small premium to the author. At the same time, the Society returned the several works presented to their authors, with the privilege of revising and completing the same and presenting them again, with such new competitors as might enter the field, at the end of the succeeding year. This work was accordingly completed and presented again ; but finding that it was the only one in the hands of the committee, it was withdrawn, the author not wishing to ask an award in a *cours seulement.*

Much pains have been taken to adapt the present work to the actual wants of the schools. Hence it begins with the elementary principles of Natural Science, and proceeds on in such a way that every step is calculated to make the succeeding one more easy.

The necessity of this will be apparent to every

one acquainted with our schools; for in them, probably not one scholar in a hundred, who ought to study agriculture, would have a previous knowledge of chemistry and natural philosophy. And yet almost every work published on the subject is written on the assumption that the reader is already a good chemical scholar. The only work which can be considered an exception to this remark, is Johnson's Catechism, which, though admirably adapted to the instruction of *children*, is really too brief and simple, to make a serious book of study in the hands of the older class of scholars in our schools.

The object of all study is two-fold, viz: to store the mind with facts, and to discipline it to serious thought, reflection, and investigation. To accomplish this we must be careful that our text-books on science are not too much *diluted* on the one hand, or too prolix and obscure on the other.

The author of the present work has aimed at a judicious medium, always endeavoring to present a clear exposition of principles, rather than a multiplication of simple facts; being fully satisfied that if the learner really understands the *object* to be accomplished, he will seldom fail to find a way to accomplish it, suited to his circumstances.

From the very complimentary opinions expressed by those who have examined the work in manuscript,

and who are every way competent to judge, the author feels confident that it will be found well adapted to the present wants of the schools and the country.

For the materials constituting much of this work, the author is indebted to the writings of Sinclair, Chaptel, Davy, Liebig, Dumas, Johnson, Dana, Jackson, Gray, Gaylord, Hitchcock, the Geological Reports of this State, &c. &c. But frequent marginal references to authorities have purposely been omitted, as calculated rather to divert the attention of the student, than to facilitate the acquisition of knowledge.

N. S. DAVIS.

New York, August 1st, 1847.

SCIENCE OF AGRICULTURE.

CHAPTER I.

CHEMISTRY.

CHEMISTRY is that science which makes us acquainted with the composition and properties of bodies, and the changes which take place between the particles of matter at insensible distances from each other.

AGRICULTURAL SCIENCE.

Agricultural science is that department of the general science of chemistry which makes us acquainted with the composition and properties of soils and vegetables, and everything connected with the formation of the first, and the growth, maturity and uses of the second.

SECT. 1. *Agents productive of Chemical Phenomena, or Changes in Matter.*

All chemical phenomena, or, in other words, all changes in the condition of matter, are the result of the influence of one or the other of the following

What is Chemistry? What is meant by Agricultural Science? With what does Agricultural Science make us acquainted?

agents, viz caloric or heat, light, electricity and attraction. These are called imponderable bodies, because they possess no appreciable weight. By some chemists, they are considered as properties essential to all bodies ; while by others, they are regarded as separate substances, though too subtle to be recognized by the ordinary properties of other matter.

CALORIC OR HEAT.

Caloric is that principle or agent which gives the sensation of heat when applied to the hand or other sensible organ. Its great characteristic quality, is that of producing expansion in other bodies, by forcing their particles of matter farther from each other, and thereby increasing their bulk. It is by this power that caloric or heat converts ice into water, and water into vapor, or makes lead and iron melt. It is by this power of expanding other bodies, and thus enabling their particles to move more freely on each other, that it becomes an agent productive of chemical changes in matter.

Caloric exists in two states—one is called latent, or combined caloric, and exists in union with the particles of matter, being neither indicated by the thermometer, nor sensible to the touch ; the other is called *free* caloric, and is indicated both by the sense of feeling, and the mercury in the thermometer.

Another marked property of *free* caloric, is its tendency to maintain an equilibrium ; by which we mean its tendency to pervade all bodies equally.

What agents produce chemical changes in matter ? What are these agents called ? Why ? Do all chemists agree as to the nature of these agents ? What are the two prevalent opinions concerning them ? What is caloric ? What is the prominent characteristic quality of caloric ? In what manner does it expand bodies ? In what way does it become an agent productive of chemical changes in matter ? In how many states does caloric exist ? What is latent caloric ? What is free caloric ?

Thus, if we place a cold body in the vicinity of several warmer ones, the caloric will be constantly communicated from the warmer to the colder one, until they all become of precisely the same temperature.

The influence of caloric or heat on vegetation, is very striking and important. This is seen not only by the changes of spring and autumn, but also by comparing the vegetation in warm or tropical regions with the colder parts of the earth.

ATTRACTION.

Attraction is the great antagonist force to caloric or heat; for while the latter is constantly tending to force the particles of matter farther from each other, the former is as constantly tending to bring them together, so as to form solid and compound bodies.

There are three kinds of attraction, viz: cohesion, attraction of gravitation, and chemical attraction or affinity.

Cohesion.—Cohesion is that force by which particles of matter of the same kind are held together, forming a continuous body. It is this kind of attraction which holds the different particles of a stone, or a piece of iron, or chalk, or wood together, in such a manner as to give it solidity and form. This kind of attraction takes place between the particles of matter of the same kind, and only when they are brought in contact with each other.

Attraction of Gravitation.—This is that power which, acting on matter in masses, causes bodies

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What are the principal properties of free caloric? Does caloric influence vegetation? What seasons and parts of the earth strikingly illustrate this? What is attraction? What influence does it exert on matter? How many kinds of attraction are there? What is meant by cohesive attraction? Can you give some examples of cohesion? What qualities does this kind of attraction impart to bodies? Under what circumstances does cohesive attraction take place? What is meant by attraction of gravitation?

placed at sensible distances from each other, to approach or fall together if left free to move. It is this power which causes bodies elevated in the air to fall to the earth. The attraction between the earth and the elevated body is mutual, but the earth being much the larger, causes all things near its surface to move towards it, unless hindered by some intervening obstacle.

It is the attraction of gravitation constantly exerted on all bodies on or near the earth's surface, which gives them what we call *weight;* but as it acts on matter in masses, it seldom becomes productive of chemical changes; and its full consideration belongs entirely to the natural philosopher.

Chemical Attraction, or Affinity, is that power which causes the particles of matter of different kinds to unite with each other, to form compound bodies. It is this kind of attraction which is the active agent in the production of nearly all the changes in the composition of bodies, which take place either in the laboratory of the chemist or in the great laboratory of nature. Chemical attraction, or affinity, is of three kinds, viz: simple affinity, single elective affinity, and double elective affinity.

Simple Affinity.—When two different particles of matter are presented to each other, as when we mix two substances held in solution by water, they combine to form a new substance. Thus if carbonic acid and lime are mixed, they unite and form carbonate of lime. This is called *simple* affinity.

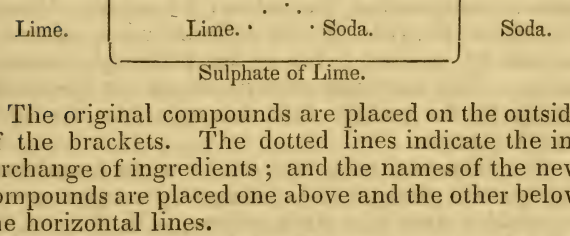
Single Elective Affinity.—When two substances

What influence does it exert on bodies, and what quality does it impart to them? Why is it not productive of chemical changes in matter? What is meant by chemical attraction or affinity? What influence does it exert on the composition of bodies? How many kinds of affinity are there, and what are they called? What is meant by simple affinity? Can you give an example of this kind of affinity? What is meant by single elective affinity?

are mixed together, one of which is already compound, and one of its ingredients leaves it to join with the other body, it is called single elective affinity. Thus, if carbonate of lime is mixed with sulphuric acid, the lime forsakes the carbonic acid, and unites with the sulphuric acid to form sulphate of lime, leaving the carbonic free or uncombined.

Double Elective Affinity.—This takes place when two compound bodies are mixed together, and a mutual interchange of ingredients takes place. Thus if we bring in contact carbonate of lime and sulphate of soda in solution, the lime elects or unites with the sulphuric acid, while the soda goes to the carbonic; and we obtain as a result, carbonate of soda and sulphate of lime. Thus making a double election or affinity.

This will be more readily understood by the following diagram:—



The original compounds are placed on the outside of the brackets. The dotted lines indicate the interchange of ingredients; and the names of the new compounds are placed one above and the other below the horizontal lines.

Hence we see, that affinity is not only the agent, or power, which causes the particles of matter of different kinds to unite, thereby forming compounds; but it may also be made our most powerful

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Give an example. What is meant by double elective affinity? Give an example and explain the diagram.

agent in effecting decompositions. For this purpose we have only to present to a compound body which we wish to decompose, another substance having a stronger affinity for some of the ingredients of the compound, than the others with which they are united. We have already given an example of this, in the case of single elective affinity. Another and more familiar one is that of the common soda powders. There tartaric acid is added to a solution of carbonate of soda, which, by its superior affinity for the soda, it decomposes; combining with the soda and setting the carbonic acid free, which rising rapidly through the solution in the form of gas, causes the effervescence. This agent or power is capable of extensive application in agriculture, in all its departments; and especially in the preparation of manures, as we shall hereafter see.

LIGHT.

Light is that substance, power or property, which is being continually emitted from the sun, and from almost all burning bodies. Chemically considered, light is composed of, 1st, colors; 2d, caloric or heat; 3d, chemical rays. These different parts are easily shown by passing a ray of light through a simple prism. The warming influence of the sun is entirely owing to the caloric that accompanies the light which it emits.

The powerful influence which light exerts over the growth of vegetables, is seen by comparing the vegetables grown in dark cellars, with those of the

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How can affinity be made the active agent in effecting decompositions? Can you explain the changes that take place in a glass of soda water? What is light? What is an ordinary ray of light composed of? How can the different parts be shown? To what is the warming influence of the sun owing? What is the difference between vegetables grown in the light, and those in the dark?

same kind in the open light of day. The former are pale, sickly and insipid, while the latter are green, rank, healthy and pungent.

ELECTRICITY.

Electricity is an extremely subtle agent, which pervades all matter, and moves with inconceivable velocity. It is developed or made sensible to us in various ways—1st, by friction, as when we rub a piece of glass or amber with a piece of silk, which is the ordinary mode; 2d, by chemical action, as when two different metals are immersed in a very dilute acid, which is called voltaic electricity or galvanism. It is the same agent, circulating around a bar of iron at right angles with the bar, which develops the phenomena of magnetism.

Electricity exists in two states—the one called positive and the other negative. One theory supposes that there are two fluids, one positive and the other negative. Another supposes that positive and negative are merely relative terms; the positive signifying that a body is charged with more than its natural quantity of electricity, and the negative less. Be this as it may, the fact is certain that whenever two bodies are brought near each other, both of which are charged with either positive or negative electricity, they *repel* each other; but if one is charged with positive and the other with negative electricity, they will mutually attract each other.

Electricity, like caloric, constantly seeks to maintain an equilibrium throughout all nature. Hence,

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What is electricity? How can electricity be excited? What is the connection between electricity and magnetism? In how many states does electricity exist? What are they called? How are these two states explained? When do bodies attract, and when repel each other? In what respect is electricity like caloric?

whenever it becomes accumulated in excess in any one point, as in the clouds for example, if there is a metallic rod, or other good conductor, elevated from the earth to the vicinity of the clouds, the excess passes silently down the rod to the earth; but if there is no such conductor, it breaks through the air with the noise of thunder, and emits a vivid flash of light, which we call lightning.

Some chemists have attempted to explain the whole phenomena of chemical affinity and combinations, on the principle of electrical attraction and repulsion; and, certainly, not without some show of plausibility, as we shall learn more fully when we come to speak of the effects of electricity on vegetation.

Sect. 2. *Classification of Bodies.*

All bodies in nature are divided into two classes, viz: simple or elementary, and compound. A simple body is one which has not yet been separated into two or more ingredients. A compound body is one made up of two or more simple bodies. There are at present known only fifty-five separate substances, called simple or elementary bodies. By the various combinations of these, all the various substances in nature are formed, whether organized or inorganic; whether animal, vegetable, or mineral.

Thirteen of these are called *non-metallic*, viz: oxygen, hydrogen, nitrogen, carbon, sulphur, phosphorus, chlorine, iodine, bromine, fluorine, boron,

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What takes place when it becomes accumulated in excess on one point? Is electricity radiated like caloric, or only conducted along those bodies called conductors? Are electricity and lightning the same? How are all bodies divided? What is a simple body? What is a compound body? How many simple bodies are known to chemists? Are all vegetable, animal, and inorganic substances made up of combinations of these? How are simple bodies divided? Can you name the non-metallic?

silicon and selenium. The remaining forty-two are called *metals*, viz: arsenic, antimony, aluminum, barium, bismuth, copper, cerium, cadmium, calcium, cobalt, chromium, gold, glucinum, iron, iridium, lithium, lanthanum, lead, molybdanum, mercury, magnesium, manganese, nickel, osmium, platinum, potassium, palladium, rhodium, sodium, strontium, silver, tellurium,titanium, thorium, tungsten, tin, tantalum, uranium, vanadium, yttrium, zirconium, zinc.

Of these, only oxygen, hydrogen, carbon, nitrogen, sulphur, phosphorus, chlorine and silicon, of the non-metallic; and aluminum, calcium, iron, magnesium, manganese, potassium, sodium, of the metallic, are of any consequence in regard to practical agriculture. These are again divided, in reference to agriculture, into organic and inorganic elements. The first four, viz: oxygen, hydrogen, carbon and nitrogen, being found in all vegetable and animal substances, are called *organic*, while all the rest are termed inorganic elements.

In this work, we shall confine ourselves to such a description of these, and their compounds, as is necessary to understand the following chapters. Before doing this, however, it is necessary to give some explanation of chemical terms.

Sect. 3. *Chemical Nomenclature, or System of Naming.*

The present system of naming substances, invented by Lavoisier, has done more to facilitate the study of chemistry than any other one thing. It is so

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Can you name those of both classes which are particularly interesting to the agriculturist? How are these divided in reference to agriculture? Which are called *organic*, and why? What is the system of naming substances called? Who invented the chemical nomenclature?

arranged that the name of every compound body is made, as far as possible, to indicate its composition. Thus oxygen, chlorine, sulphur, &c., combine with the metals, and form substances which are called oxides, chlorides, sulphurets—as oxide of iron, chloride of iron, or sulphuret of lead.

But oxygen or chlorine may unite with the same metal in more than one proportion, forming one, two, three or more compounds. These are distinguished from each other by prefixing the Greek numerals, prot, deut, trit and per: thus, there may be a prot-oxide, deut-oxide, trit-oxide and per-oxide of iron; the first signifying the lowest quantity of oxygen, and the last the highest. And the same of the proto-chlorides, deuto-chlorides, proto-sulphuret, &c.

But perhaps no names appear more frequently in chemistry than acids, alkalies, salts and base. By acid, we mean any substance which will change the vegetable colors to red, and unite with an alkali, oxide, or other base, to form a neutral compound possessing properties essentially different from either of the ingredients which enter into its composition, and which compound is called a salt.

Most of the acids are formed by the combination of oxygen with some other simple body, as carbon, nitrogen, sulphur, phosphorus, &c. And they all take their name from the substance with which the oxygen combines. Thus we have carbonic, nitric, sulphuric, phosphoric acids, &c. But oxygen com-

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On what principle is it formed? When oxygen, chlorine, or sulphur combines with the metals, what are the compounds called? If these substances combine with any given metal in more than one propoetion, how are the compounds distinguished from each other? Which prefix indicates the highest and which the lowest degree of oxidation, &c.? What names appear very often in chemistry? What is an acid? How are most acids formed? What determines the name of each?

bines with some substances in more than one proportion, forming two, three or four different compounds possessing acid properties. These are distinguished by the terminations *ous* and *ic*, and the prefix *hypo*. Thus the two acid compounds of phosphorus and oxygen are called phosphorous and phosphoric acids; the first containing the least and the last the most oxygen. Again, we have four acid compounds of nitrogen and oxygen, viz: the hypo-nitrous, the nitrous, the hypo-nitric, and the nitric acids.

Chlorine also combines with some substances, forming acid compounds. Thus chlorine and hydrogen unite and form the chloro-hydroic acid, a compound long well known by the common name of muriatic acid. But these compounds are distinguished by the same terminal letters as when oxygen enters into their composition.

The term alkali is applied to those compound substances which possess the property of changing the vegetable blue colors to green, and uniting with acids to form neutral compounds, termed salts. The principal alkalies are potassa, or potash, soda, ammonia, and lime. This last, however, together with magnesia and manganese, are generally called alkaline earths. But as we have acids terminating in *ous* and *ic*, so the neutral compounds, or salts, which they form with alkalies or oxides, terminate in *ite*

Does oxygen combine with other substances in more than one proportion to form acids? How are they distinguished from each other? How many acid compounds of oxygen and nitrogen are there? How are they distinguished from each other? Let the pupil write them on the black-board, and point out the relative proportion of oxygen in each. Does chlorine ever form acid compounds with other bodies? How are they distinguished? What is the composition and proper name of muriatic acid? What is meant by an alkali? Can you name the principal alkalies? What is the compound formed by the union of an acid with an alkali called? How do you distinguish a *salt* formed by an acid terminating in *ous*, from one in *ic*?

and *ate*. Thus sulphurous acid and soda form sulphite of soda, and sulphuric acid and soda form sulphate of soda. And so of all the other similar compounds with acids.

Sometimes the same acid combines with the same base, in more than one proportion. These are distinguished by prefixing the term *bi* to the second compound; as the carbonate and bi-carbonate of soda, &c. The word *base* is used in a general sense, to signify any alkali, earth, or metallic oxide which is capable of combining with an acid. And a *salt* is any neutral compound of an acid with a *base*. Thus carbonate of soda is a *salt*, the *base* of which is soda.

Sect. 4. *Laws of Chemical Combinations.*

1st. The composition of every compound substance is fixed and invariable. The ingredients are not only always the same, but they are always combined in the same relative proportion. Thus oxygen and hydrogen combine in the proportion of one of hydrogen, by weight, to eight of oxygen, to form water; and in no other proportion can water be formed. The addition of one proportion more of oxygen, makes a liquid of a highly corrosive and poisonous nature.

2d. The relative quantities in which bodies unite, may be expressed in proportional numbers. Thus eight parts of oxygen combine with fourteen of nitrogen, sixteen of sulphur, thirty-six of chlorine, and six of carbon. Not only do these various substances

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When the same acid combines with the same base in more than one proportion, how are the compounds distinguished? Write an example. What is a *base*? What is the first law of chemical combinations? What is the composition of water? Do the ingredients or elements of any given compound always unite in the same relative proportion? What is the second law of combinations? Give an example.

hold this relative proportion when combined with oxygen, but they remain the same when they combine with any other body, or with each other. The same law applies to compound bodies. Thus water is composed of oxygen 8 and hydrogen 1, therefore its combining number for all substances is 9. Sulphuric acid is composed of one proportion of sulphur 16, and three proportions of oxygen 24, hence its combining number is 40. And so in all other compounds.

3d. When one body A combines with another body B, for example, in more than one proportion, the quantities of A in the second, third, and fourth compounds, will be simple multiples of the first by a whole number. Thus nitrogen combines with oxygen in the ratio of one proportion 14, to 8, 16, 24 and 32 of oxygen. There are a few substances which apparently form an exception to this rule, but they are immaterial to our present purpose.

4th. Gases or airs unite with each other by *volume*, in the simple ratio of 1 to 1, 1 to 2, 1 to 3, &c. Thus 1 cubic inch of oxygen will combine with 2 cubic inches of hydrogen to form water, but never 1 cubic inch to $1\frac{1}{2}$.

5th. The respective quantities of any number of alkaline, earthy, or metallic bases, required to saturate a given quantity of any acid, are always in the same ratio to each other, to whatsoever acid they are applied. Thus if *two* parts of soda will saturate as much sulphuric acid as *three* parts of potash, their power of saturating every other acid will be in the same ratio to each other.

Do the several bodies preserve the same relative proportion towards each other when combining with all other bodies? Does this law also apply to compound bodies? What is the third law of combinations? Give an example. Are there any apparent exceptions to this rule? What is the law of combination in regard to gases? What is the fifth law of combinations?

It will be seen by the foregoing rules, that in science, we use the words *combine* and *combination* in a strict and specific manner, which should be distinguished from simple mixture. If we mix ever so intimately sand and saw-dust, salt and water, or flour and water, no particular change takes place in the properties of the mixed substances; and they may be easily separated again. On the other hand, when two substances *combine*, their particles enter into a new arrangement, and a new substance is formed with properties different from either of its ingredients. Simple *mixtures* may be made in any proportions, but all *combinations* are subject to the laws which we have stated.

Again we have used the word *saturate*. When any acid or fluid has united with, or dissolved, as much of another substance as it can be made to, it is said to be *saturated*. Thus water is saturated with common salt by adding as much as it will dissolve, &c.

CHAPTER II.

ORGANIC ELEMENTS.

All substances in nature exist in the state of solids, liquids, or gases. The four simple substances belonging to this class, viz: oxygen, hydrogen, carbon and nitrogen, constitute from 90 to 98 per cent. of the substance of all living plants; as well as the entire bulk of the air and water which belong to our

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What is meant by a combination in chemistry? What is the difference between a *combination* and a mixture? Give an example of each. What is meant by the word *saturate*? In what state do all the substances in nature exist? What simple substances are called organic elements? Do these elements enter into the composition of all living plants?

earth. Oxygen also exists in large quantities in combination with the mineral substances, which make up the solid crust of the earth; and the immense beds of coal, graphite, &c., are nearly pure carbon.

Oxygen.—This substance, when pure, is a colorless, tasteless, inodorous gas; highly elastic; a little heavier than atmospheric air; is very sparingly absorbed by water; is attracted to the positive pole of the galvanic battery, and hence is itself an electro-negative, and a powerful supporter of combustion and animal life. It is the substance which enters into combination with combustible matter, with such rapidity as to evolve light and heat, as exhibited in all our fires; and without its presence neither animal nor vegetable matter can either grow or maintain its vitality. It exists abundantly in nature, forming one-fifth of the atmosphere, and eight-ninths of the weight of all the water on the globe; besides being an ingredient in all animal and vegetable substances, as well as many inorganic solids.

Oxygen possesses, perhaps, a more extensive range of affinities than any other substance; forming, with other simple elements, oxides, alkalies and acids. It is readily obtained in its gaseous form, by heating to redness the per-oxide of lead (red lead) or manganese (black oxide of) in an iron retort or gun barrel, and collecting the gas in a glass jar or receiver over water, in the same manner as hydrogen. Fine iron wire may be burned in this gas when pure, as readily as paper in the open air. And when mixed with twice its bulk of hydrogen gas, it ex-

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How large a proportion of all plants consists of organic elements? Where else are they found besides in vegetables? What is oxygen? What are its prominent qualities? Is it electro-negative or positive? Does it take part in ordinary combustion? What is its influence on animal and vegetable life? In what substances is oxygen found abundantly; and in what proportion? What are its compounds with other simple substances called? How can oxygen be obtained in a separate state?

plodes violently on the application of a lighted taper or an electric spark. Its combining number for all other substances is 8, and its representative letter O.

Hydrogen.—This, like the preceding, is a highly elastic, colorless, tasteless gas; very sparingly absorbed by water; will not support combustion or animal life; but readily takes fire itself, when brought in contact with a lighted taper in the open air, and burns with a pale, blue flame; is attracted to the negative pole of the galvanic battery, and hence termed an electro-positive body. It is regarded as the lightest substance known, being sixteen times lighter than oxygen, and 200,000 times lighter than mercury.

Hydrogen is found in small quantities in most liquids, in nearly all vegetable and animal substances, but chiefly in water, of which it forms one-ninth part by weight. It is easily obtained by adding dilute sulphuric acid (oil of vitriol) to zinc or iron filings in a glass retort, and collecting the gas over water, as illustrated by the accompanying figure.

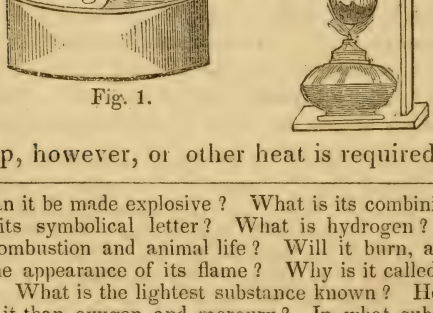

Fig. 1.

No lamp, however, or other heat is required in the

How can it be made explosive? What is its combining number, and its symbolical letter? What is hydrogen? Will it support combustion and animal life? Will it burn, and if so, what is the appearance of its flame? Why is it called electro-positive? What is the lightest substance known? How much lighter is it than oxygen and mercury? In what substance is hydrogen most abundant? How is hydrogen obtained?

process. In this process, the oxygen of the water in the dilute acid goes to the zinc or iron, while the hydrogen is set free, or left to assume its gaseous state. It is this gas which is used to fill balloons. Its combining number is 1, and its symbol, or representative letter, H.

Nitrogen.—Nitrogen is also a gas, which cannot be distinguished from the two preceding by its sensible qualities. Its properties seem to be mostly of a negative character; being neither a combustible, nor a supporter of combustion or animal life; and apparently merely a diluent of oxygen in the atmosphere. It exists abundantly in animal substances, and forms four-fifths of the bulk of the atmosphere. It exerts an important influence over the growth of vegetables, and readily enters into combination with some other substances, forming an active and energetic class of compounds. It also belongs to the class of electro-positive bodies. Its combining number is 14, and its symbolical letter, N.

Carbon.—This substance enters more largely into the composition of vegetable substances than any other simple body in nature, forming from 20 to 55 per cent. of their bulk. The purest form of carbon is the diamond. The next is common charcoal, the properties of which are too well known to need particular description.

One of the most important properties of charcoal

What changes take place in this process? What is hydrogen gas used for? What is its combining number and symbolical letter? What is nitrogen? What is there peculiar in its properties? In what is it found most abundant? Does it exert any influence on the growth of vegetables? Is it attracted to the negative or positive pole of the galvanic battery? What is its combining number and symbolical letter? Is carbon a solid or liquid? In what form is it most pure? What is its most common form? How large a proportion of the bulk of vegetables does carbon form?

to the agriculturist, is its power of absorbing gases. Thus, freshly burned charcoal from wood will absorb 95 times its own bulk of ammoniacal gas ; 55 times of sulphuretted hydrogen, and 9 times of oxygen.

The combining number of carbon is 6, and its symbolical letter, C. It has a strong affinity for oxygen, with which it combines to form the well-known and widely diffused gas, called carbonic acid gas, or fixed air, which is so frequently found in caves, wells, &c. ; and which is absorbed in large quantities by water, to which it gives a lively, sparkling appearance, and sour taste. It is composed of carbon 6 parts, and oxygen 16, making its combining number 22.

This acid gas always exists in the atmosphere in small quantities, and is the chief source from which plants derive their carbon. It may be easily obtained for examination by adding dilute muriatic acid to the common carbonate of lime (chalk or marble) in a glass flask, and collecting the liberated gas in a receiver inverted over mercury.

It is a fact worthy of notice, that the four elementary substances above described not only make up from 90 to 98 per cent. of the entire bulk of vegetables, but they also constitute a large share of the inorganic materials of our globe. They constitute the entire bulk of the air and water, while the oxygen and carbon also form no inconsiderable portion of the more solid crust of the earth. Hence, they

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What remarkable property does carbon, in the form of charcoal, possess ? How much ammoniacal gas will it absorb ? Has carbon any affinity for oxygen ? In what proportion does carbon and oxygen unite ? In what state does the compound exist, and what is it called ? In what places is it often found ? What qualities does it impart to water ? From what source do plants obtain their carbon ? How may carbonic acid gas be obtained ?

are always present in sufficient abundance for all the purposes of vegetation; their supply being, indeed, inexhaustible.

INORGANIC ELEMENTS.

The inorganic elements of vegetables, though more numerous than the organic, nevertheless constitute but little more than two per cent. of their bulk. They are chlorine, phosphorus, silicon, aluminum, calcium, magnesium, potassium, sodium, manganese and iron.

But though these substances form so small a portion of the living plant, they are still equally important and essential to its growth and full maturity. And as they are more limited in quantity, and less universally diffused over the surface of the earth than the organic elements, their thorough study is even more important to the agriculturist. Hence, we shall give a short description of each, that the nature of their compounds, and the manner in which they are made to serve as nourishment for plants, may be more readily understood.

Chlorine.—Chlorine is a gas of a yellowish green color, disagreeable odor, astringent taste, and very suffocating and poisonous when inhaled into the lungs. It is twice as heavy as atmospheric air—supports combustion feebly—is absorbed by cold water—destroys animal and vegetable colors—and becomes liquid under a strong pressure.

Are the four organic elements always present in quantities sufficient for the purposes of vegetation? Can you name the inorganic elements of vegetables? How large a portion of the bulk of vegetables do they generally form? Are they always essential to the full maturity of vegetables? Are they as universally and abundantly diffused over the earth as the organic elements? What are the properties of chlorine? What effect does it have on vegetable colors?

This gas enters into combination with various substances, forming compounds, among the most useful of which is its union with sodium in the form of common salt, and with hydrogen in the form of muriatic acid. The common salt exists abundantly in nature, and forms a very useful manure for some soils, while its value for stock and culinary purposes is too well known to need mention.

Silicon.—Silicon is a simple, solid substance, the properties of which, in its separate state, are imperfectly known. By some it is ranked with the metals. When combined with oxygen, it forms the well-known substance called silica, or silex, which enters largely into the composition of many rocks, sand, &c.; and hence is an ingredient in most soils. It also enters into the composition of many vegetable substances, such as the various grasses, grains, &c. Quartz, or rock crystals, are also nearly pure silex.

This substance is an essential ingredient in fertile soils, and is used extensively in the manufacture of glass. Silica also acts the part of an acid, and combines with potassa, soda, lime, alumina and magnesia. These compounds are called *silicates*, and are mostly insoluble in water. These silicates and silex constitute from 70 to 90 per cent. of most soils.

Aluminum.—In its pure state aluminum is a gray, slightly cohesive powder, of a shining metallic lus-

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Does it readily enter into combination with other substances? What are its most useful compounds? Is the chloride of sodium a common salt found ready formed in nature? In what way is this particularly useful to the farmer? What is silicon? What is the substance formed by its union with oxygen called? Does silex enter into the composition of vegetables? In what form is it found most pure? For what is it extensively used? Does it ever act as an acid? How large a proportion of most soils is formed of silica and its compounds? What is aluminum? Can you describe it?

tre, insoluble in water, and having a strong attraction for oxygen, with which it combines to form alumina, an ingredient in the well-known substance called alum. Alumina also forms the basis of all clays, and is an ingredient in the argillaceous rocks, as well as the feldspar, which enters into the composition of both the primitive and secondary formations. Alumina is composed of 27·4 parts of aluminum and 24 parts of oxygen.

Next to silica, alumina is the most abundant ingredient in the rocks and soils of the globe. It is chiefly derived from the decomposition of the feldspathic minerals, or argillaceous rocks. Combined with a small proportion of silica, or silicic acid, it forms common clay, and gives to the soil its adhesive qualities. Alumina also possesses the property of absorbing considerable quantities of water and some of the gases, particularly the ammoniacal gas, and of retaining them in the soil for the use of plants.

Phosphorus.—In its pure state, phosphorus is a soft, friable solid, having a strong attraction for oxygen, with which it combines rapidly; emitting dense white fumes, which are rapidly absorbed by water. This compound of phosphorus and oxygen is intensely sour, and is called phosphoric acid. This acid, when united with lime, soda, ammonia, &c., enters into the composition of many vegetables, and is hence of much importance to the agriculturist.

What does it form when combined with oxygen? In what kind of rocks and soils is it most abundant? Of what is alumina composed, and what is the proportion of its ingredients? From what source is it principally derived? What qualities does it impart to the soil? With what is it generally combined when in the form of common clay? What substances will it absorb? Can you give a description of phosphorus and its qualities? What does it form when combined with oxygen? Does phosphoric acid enter into the composition of vegetables?

Phosphate of lime forms a large share of the solid part of bones, from which the pure phosphorus is principally obtained. It is to this ingredient that bones owe their value as a manure. This compound of phosphoric acid and lime, although not an abundant product in nature, has been discovered in the rocks of two or three localities in this State, in quantities sufficient to render it valuable as a manure.

Calcium.—This is a white, metallic substance, and when combined with oxygen, exists abundantly in nature, forming the common lime or quick-lime of the kiln. It is this combination of calcium and oxygen which forms the basis of all the limestone rocks, shells, plaster of paris, marble, &c. It is strongly alkaline in its properties, readily combining with acids, and forming some of the most abundant products in nature.

Its union with carbonic acid forms the well-known carbonate of lime, (common limestone,) which alone makes up whole ranges of mountains; while with the sulphuric acid it forms the sulphate of lime, or gypsum, or plaster of paris, as it is variously called; which is scarcely less abundant. Though lime and its combinations are thus abundant, it is found in the soil in very small quantities only. But it exerts an important influence on vegetation, and enters into the composition of many plants.

Magnesium.—This substance much resembles

What constitutes the solid part of bones? What renders bones valuable as a manure? Is phosphate of lime found native in the rocks of this State? What is calcium? What is the composition of common, or quick-lime? What forms the basis of limestone rocks, shells, &c.? Is quick-lime an alkali or an acid? With what is it combined in common limestone? With what in gypsum or plaster of paris? What is the proper name of gypsum? Are these compounds of lime abundant in nature? Are they abundant in most soils? Do they exert any influence on vegetation? What does magnesium resemble?

calcium, both in its properties and its influence on vegetation. It combines with oxygen to form an alkali, called magnesia. It exists in some rocks and soils, but only in small quantities.

Manganese.—Manganese is of but little importance to the agriculturist. In combination with oxygen, however, it forms an alkali, which is calculated to neutralize any acids with which it comes in contact; and might thereby prove beneficial to some soils. It exists in nature, combined with oxygen, in black, earthy masses, which are unaffected by either air or moisture.

Potassium.—This is a soft metallic substance, possessing so strong an attraction for oxygen, that when brought in contact with water, it decomposes it, and unites with its oxygen so rapidly as to produce combustion. Hence a particle of it placed on the wick of a candle or taper, and touched with a piece of *ice*, will take fire. Thus, united with oxygen, potassium forms the well-known caustic alkali, called *potash* or potassa.

Potash also unites readily with carbonic acid, forming a carbonate and bi-carbonate of potash, well known as the common *pearlash* and *salæratus*, so much used for culinary purposes. It enters as a necessary ingredient into the composition of a great variety of vegetable substances, and is found widely diffused throughout nature. It is found in the greatest abundance in the granite, gneiss and mica rocks, and the soils derived therefrom, together with the

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What does it form with oxygen? Does it exist in soils, rocks, &c.? Is manganese of much importance to the agriculturist? What is potassium? What takes place when water or ice is brought in contact with potassium? What is formed by the union of potassium and oxygen? Does potash unite with carbonic acid in more than one proportion? What are the compounds called? Is it of any importance in the growth of vegetables? In what kind of rocks is it found most abundant?

argillaceous or clayey formations. Potash also forms an abundant ingredient in the ashes of wood.

Sodium.—Sodium is also a metallic substance, much resembling potassium in its appearance and properties. It possesses a strong attraction for oxygen, and unites with it to form soda; which is the basis of that well-known alkaline carbonate used for making *soda powders.*

Like potash, soda combines with carbonic acid in two proportions, forming a carbonate and bi-carbonate of soda. It exists in small quantities in albite, mica and basaltic or volcanic formations, and abundantly in chloride of sodium, or common salt. It enters into the composition of many vegetables, though it is far less important in that respect than potash, which it resembles in its action on soils and vegetation.

Iron.—Iron is a metal too well known to need description here. It enters in some form into the composition of almost every kind of soil; and, indeed, into the composition of almost all vegetable and animal substances. In the soil, it is generally found in combination with oxygen, forming an oxide or *common iron rust.* But sometimes the oxide of iron is combined with an acid, forming a sulphate or carbonate of iron. The quantity of iron in different soils varies from 1 to 12 or 15 per cent.

Having now briefly presented the general agents or powers which are productive of chemical changes

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In what other substances does it exist? What does sodium resemble? For what has it a strong attraction? What is its compound with oxygen called? In what substances is it found in nature? Does soda enter into the composition of vegetables? What does it resemble in its action on vegetation? What is iron? Is it often found in the soil? Is it found in vegetable and animal substances? With what substances is it found in combination in the soil? How large a quantity of iron is usually found in the soil?

in matter; the laws which govern chemical combinations; together with a short description of those simple or elementary substances which, in their various forms of combination, not only make up the mass of our globe, but also the entire bulk of organized vegetable matter, we proceed in the following pages to consider—1st, the formation, classification and composition of soils; 2d, the composition of vegetables, and the sources from which their ingredients are derived; 3d, the means possessed by man for fertilizing the soil, and adapting it to the growth of the various crops which he may desire; 4th, the preparation of manures, their composition and adaptation to particular soils; 5th, the best modes of analyzing vegetable substances, soils, &c., together with tables showing the composition of the various grains, grasses, root crops and soils, according to the most accurate analysis; 6th, practical agriculture and horticulture, including the growth of grains, roots, grasses, &c.

CHAPTER III.

Sect. 1. *Formation of Soils.*

The entire crust of our globe is composed of rocks, of various forms, composition, and properties. The mixture of stones, clay, loam, sand, &c., covering the surface of these rocks to a greater or less depth, is called soil. The principal ingredients in the soil

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Of what is the entire crust of the globe composed? What is meant by soil? What relation exists between the rocks and the soil?

generally correspond with those of the rocks beneath, and hence geologists and chemists have almost unanimously represented the former as having been derived from the latter, by the gradual disintegrating or crumbling influence of air, water, vegetable substances, &c.

Nearly all rocks contain more or less of the metallic substances which we have described, particularly iron and manganese. These possessing a strong attraction for the oxygen of the air, readily enter into combination with it, wherever they come in contact, forming oxides which crumble to pieces. Or if, as is often the case, the iron is previously combined with sulphur, forming pyrites, or sulphuret of iron, then oxygen converts the two into sulphate of iron or copperas; which, being soluble in water, is dissolved and brought in contact with other ingredients, such as potash and lime, when still other combinations are formed, until the whole rocky mass falls to pieces.

In many of these changes, the volume of the new compound is increased, and the rock thereby split so as to admit water into the crevices; the freezing of which opens the seams still wider, and hastens the dissolution. And no sooner do the air and water thus commence the work, than various vegetable substances, such as lichens, mosses, &c., spring into existence, and extend their roots into the crevices of the rocks—not only keeping them moist, but, with the rocks and moisture, forming a galvanic

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What agents are active in the formation of soil from rocks? What metallic substances are often found in rocks? What changes take place when they are exposed to the atmosphere? What changes occur when sulphur enters into the composition of the rocky mass? What is the combined influence of water and frost? What kind of vegetables spring into existence first in new or forming soils? What further influence do these exert on the rocks?

apparatus of great decomposing or disintegrating power.

Again, these vegetable substances, in a state of decay, form various acids; which, in their turn, act still further in destroying the composition of rocks and stones. By the combined influence of all these agents, constantly acting from century to century, the solid portions of our earth are dissolved, and their rich storehouse of minerals gradually unlocked to nourish the vegetable creation, and beautify the earth.

That these agents do possess the power here ascribed to them, is evident from the fact, that places are found in some of the Eastern States of this Union, where the gneiss rocks have been penetrated to the depth of fifteen feet. In common language the rock is said to rot. But the soil does not always remain at the place where it is formed, for the winds and moving waters are constantly changing its location.

From the falling rain, and the rills that trickle down the sides of the mountains, carrying the soluble materials, sand and gravel with them to the mighty rivers, which, in their course, break through rocks and hills, and precipitate their substance into the valleys, and the resistless, sweeping, eddying flood, which sometimes sweeps over whole countries—all have a powerful agency in transferring the ingredients of soils from the place of their formation, on the hills and mountains, to other and sometimes distant places in the valleys below. It is from such causes that we often find the composition of soils, particularly those of alluvial origin, (such

What substances are formed by the decay of these vegetables? What has been the result of the action of all these agents during past centuries? What evidence have you of their action? Does the soil always remain at the place where it is formed? What agents are capable of removing it?

as have been deposited from water,) very different from that of the rocky masses which lie beneath them. And it is owing to the same causes that we find the soil varying in depth, from a few inches, or none at all, on the sides and tops of hills and mountains, to more than one hundred feet in some valleys.

The soil over the whole earth will not probably exceed an average depth of twelve or fifteen feet. When we remember that the mean diameter of the earth is 7,911 miles, we shall cease to wonder how so great a mass of soil could have been formed by the operation of the causes which we have named, in the space of 6000 years.

Though we have applied the term *soil* to the whole mass of heterogeneous or mixed matter lying over the rocky crust of the globe, yet, in common language, it is confined entirely to that part of the earth's surface which is more or less mixed with decaying vegetable matter, and which varies in depth from three to twenty inches. It is this part which chiefly concerns the farmer; and it is, hence, to this that we shall mainly confine the term in the following chapters of this work.

Sect. 2. *Classification of Soils.*

Soils have been variously classified by different writers, some arranging them solely in regard to their geological origin, and others according to their chemical composition. The most recent writers of

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Do we, then, ever find the soil different in composition from the rocks that lie beneath it? Where do we find soil of the greatest depth, and where the least? What is probably the average depth of the soil over the globe? What is the diameter of the earth? To what is the term soil more properly restricted in agriculture? In what way have different writers classified soils?

the former class have divided soils into alluvial, diluvial, tertiary, secondary, and primary.*

By alluvial soils, are meant those formed by depositions from rivers, lakes, &c.; and they vary according to the source from which they are brought. These soils form extensive tracts of land along the valleys of rivers; such as the Mohawk and Genesee of this State; the Mississippi, with its host of tributaries, in the west; the Connecticut, in the east; and the Susquehanna, Potomac, Savannah, and others of the Atlantic States. Most of these soils contain much vegetable matter, and are productive. But some, particularly along the Atlantic coast, are sandy and barren.

PEATY SOILS.

In the class of alluvials may be placed those called peaty soils; which are composed, in a great measure, of vegetable matter in a partially decomposed state.

DILUVIAL, DRIFT, OR TERTIARY SOILS.

By some of the older geologists, the diluvial soils are described separately from the tertiary, and were supposed to have their origin in glaciers or slides at some remote period when the position of the earth was different from what it is at present.

But more extended observation shows them to have a common origin from the *tertiary*, or third

* See Gray's Agricultural Chemistry, page 231.

What are the classes founded on their geological origin? What is meant by *alluvial?* Where are alluvial soils generally found? What do these soils generally contain? Are they always productive? What were the views of some of the older writers in regard to the diluvial and tertiary classes? What was the supposed origin of the diluvial? Are the diluvial and tertiary classes separate? To what geological formation do they belong?

geological formation. This is generally made up of sand, clay, and mud, in alternate layers, and often not hardened into rock. Of course the soil will partake of the mixed nature of the ingredients from which it is derived.

It seems to be a fact also, that nearly all this variety of soil in our country, or rather the geological formation from which it is derived, has been moved in a southern or south-western direction.

This is explained by modern geologists on the supposition, that at the period of its formation, this continent was wholly or in part submerged beneath the waters; and that the natural oceanic currents settling in from the north, and often containing immense glaciers of ice, brought the materials for this formation, and gradually deposited them in alternate layers or strata, in the position they now occupy. This process was doubtless facilitated, as well as its regularity sometimes disturbed, by counter-currents from the equatorial regions.

The soils derived from this source, are most commonly found occupying the middle space between the alluvial or bottom lands and the mountainous regions; and are hence very extensive, and in most cases fertile.

SECONDARY SOILS.

These are derived from the secondary strata or layers of rocks; and as geologists include in this division a great variety of formations, viz: the cretaceous or chalky, calcareous or limy, silurian or

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What constitutes the chief part of this formation? What remarkable fact seems to be connected with this formation in our country? How is the fact explained? What were the directions of the supposed currents? What was the influence of counter-currents from the equatorial regions? In what position are the most of the soils of this class found? What is their general agricultural character? What is meant by secondary soils?

graywacke, argillaceous or slaty limestone, pudding stone, &c., the soils present a great variety of ingredients, and are often mixed with large quantities of fossil or animal and vegetable remains.

PRIMARY SOILS.

The primary class of soils is derived from the first or primary stratified and unstratified rocks. To this class of rocks belong the argillaceous, mica and talcose slate; primitive limestone; gneiss, sienite, hornblende, porphyry and granite. Hence the soils of this class also present as great a variety of character as the rocks from which they are derived. They are generally found in high and mountainous regions, particularly in the New-England States.

It should be observed, that this classification of soils, however correct in a geological sense, is still of but little practical value to the farmer. To him that classification based on the *composition* of the soil is much more intelligible, as the name of each variety or class immediately suggests the predominating ingredient contained therein. But neither the preceding arrangement, nor the study of geology, on which it is based, should be neglected by the scientific agriculturist.

Neither should the important truth ever be lost sight of, that the various rocks, stones, sand, &c., are the great storehouses of nature, in which are

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What formations are included in this division? Are the soils of this class very uniform in their composition? What objects of interest are often found abundantly in this class? What is meant by primary soils? Are all rocks stratified? What are the principal rocks belonging to the primary division? In what situations are soils of this class generally found? Is the foregoing classification of soils of much value to the farmer? Why not? What classification is better suited to the purposes of the agriculturist? What, in reference to agriculture, constitutes the great *storehouses* of nature?

locked up the alkaline, earthy and metallic substances essential to the growth of vegetables ; and that the winds, the moving waters, the sunshine and the frost, are so many keys to unlock these storehouses, and gradually scatter their fertilizing contents over the fields of the husbandman.

Soils, when arranged according to the predominating ingredients of their composition, are divided into, 1st, siliceous or sandy ; 2d, aluminous or clayey ; 3d, calcareous or limy ; 4th, loamy ; 5th, peaty or carbonaceous. These will be more fully explained in the following section.

Sect. 3. *Composition of Soils.*

SILICEOUS.

The siliceous soils comprise all those of a sandy or gravelly character, the predominating ingredient in which is silex or silica. They doubtless originate mostly from the granite, gneiss, mica and sandstone rocks. And whether the soil remains at the place of its formation, or is carried to other regions, forming alluvials or diluvials, it in all cases contains from 65 to 90 per cent. of siliceous earth or sand.

The soil in the southern and eastern parts of New-York, together with the New-England States, contains an average of about 66 per cent. of silica or sand earth ; from 10 to 16 of alumina or clay ; from 1 to 10 per cent. of carbonate, phosphate and sulphate

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What are the keys to unlock those storehouses ? What are the classes of soils when arranged according to their composition ? What soils are included in the class called *siliceous* ?— From what do they mostly originate ? How large a proportion of siliceous earth or sand do they contain ? How large a proportion of silica or sand is there in most of the soils of eastern New-York and New-England ? What are the other principal ingredients in the same soils ?

of lime; from 0.5 to 2 per cent. of potash; from 1 to 5 per cent. of iron; and a trace of magnesia, soda, and ammonia; with from 5 to 10 per cent. of vegetable matter. The middle and western parts of New-York contain a much larger portion of alumina.

An accurate analysis of the soil taken from a cultivated field on the east side of the Chenango river, near the village of Binghamton, gave the following result, viz :—

Silex and silicates,	74.2 per cent.
Soluble vegetable matter,	8.3 "
Insoluble, " "	6.6 "
Phosphate and carbonate of lime,	3.5 "
Potassa,	3.0 "
Oxide of iron and alumina,	3.3 "
Soda and loss,	1.1 "
Magnesia,	trace.
Manganese,	trace.

This soil is very fertile for wheat, corn, oats, potatoes, clover, &c.

All siliceous soils are light and porous, possessing but little tenacity, and hence allowing water and other substances in solution to pass through them with facility. They are generally warm and dry, and hence very favorable to the early commencement of vegetation in the spring. But they part with manures rapidly, and are also more liable to excessive droughts in the summer than most other soils.

Siliceous sand, or silica, forms from 40 to 45 per cent. of the entire crust of the globe, and is the prin-

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What ingredient is greatly increased in quantity, in the middle and western part of New-York? To what class of soils does the specimen analyzed from the valley of the Chenango river belong? What are the prominent characteristics of all siliceous soils? Are they favorable to the early commencement of vegetation? To what objections are they liable? What proportion of the entire crust of the globe is composed of silica?

cipal substance which gives lightness and porosity to all soils. Most siliceous soils are productive, especially for corn, rye, oats, potatoes, clover, &c. But when the silica or sand exceeds 90 per cent., the soil is barren.

ALUMINOUS.

Aluminous, argillaceous or clayey soils, include all those in which the alumina exists in such quantities as to give the soil a decidedly compact and tenacious character. Alumina exists in all soils, and forms about 14 per cent. of the surface of the earth. It is chiefly derived from such rocks as contain feldspar, and from argillaceous or clay slate. This earth is seldom found pure in the soil, but is generally combined with silicic or crenic acids; and, from its origin, is also combined with an abundance of potash, and most, if not all those substances necessary to form a fertile soil.

But if the alumina greatly predominates, the soil is so heavy and tenacious as to prevent the water from draining off; and is consequently cold, wet and unproductive; forming the common clay beds. A pure aluminous soil, like one entirely siliceous, is wholly barren. But when it is mixed with a sufficient quantity of siliceous sand, gravel and lime, to give it looseness and porosity, it forms a loam the most fertile of all soils.

For what crops are siliceous soils generally adapted? When the silica exceeds 90 per cent., what is the character of the soil? What is meant by aluminous soil? How large a proportion of the earth's surface is composed of alumina? From what class of rocks is it chiefly derived? With what is it generally combined in the soil? What if the alumina greatly predominates over the other ingredients? What does it then form? What other ingredients are capable of rendering an aluminous soil very fertile?

Such is essentially the soil in most parts of western New-York. There is a base of aluminous earth or clay, with sufficient sand and limestone (carb. of lime) to give it looseness of texture, and hence it forms one of the best *wheat* soils in the world. The richest aluminous soils are those of alluvial origin, particularly those found at the mouths of some rivers, where the products of the sea have been intermixed with them, and the whole converted by cultivation into deep fine loam.

CALCAREOUS OR LIMY SOILS.

Lime, in some form, exists in small quantities in all fertile soils; but, as a predominating ingredient, it is comparatively of very limited extent. For though the carbonate and sulphate of lime (common limestone, and gypsum or plaster) form extensive strata or layers of rocks, and are extensively distributed over the earth, yet they constitute but a very small share of the soil itself.

In our own country, the soils average less than 3 per cent. of the compounds of lime, the most abundant of which is the phosphate; while most of the countries of Europe are stated to contain from 6 to 20 per cent. This probably accounts for the very great value of lime as a manure, when applied to most of the soils of New-York and New-England.

Calcareous or limestone rocks are supposed to form nearly one-seventh of the entire crust of the

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What is the character of the soil in western New-York? For what crops is it peculiarly adapted? Where do we find the richest alluvial soils? What is meant by calcareous soil? Is lime generally found abundant in all soils? How large a per cent. of the compounds of lime is generally found in the soils of this country? Do the soils of Europe contain more or less lime than our own? Why are the compounds of lime valuable as manures when applied to most of the soils in this country? How large a proportion of the entire crust of the globe is composed of lime and its compounds?

earth. They exist abundantly in the United States, especially in the form of carbonates. And the reason why they form so small a part of the soil, is on account of the resistance which their composition and density offers to the ordinary causes of disintegration.

The compounds of lime enter into the composition of growing plants, and they furnish a chief ingredient in the bones of animals. Lime generally exists in the soil in combination with acids. In the bones of animals it is always united with phosphoric acid, in the form of phosphate of lime—sometimes called bone earth.

LOAMY SOILS.

This term has been applied to a class of soils not distinct from the preceding classes in composition; but, in fact, made up of a mixture of all the others, in such proportions as to avoid the extreme dry and sandy nature of the siliceous, as well as the too great tenacity and heaviness of the argillaceous or clayey. In a natural state, this kind of soil is seldom found, except in old and deep alluvial formations. But there is no soil which cannot be converted into loam by a continued course of proper cultivation. Thus the liberal addition of sand and gravel from the nearest sand-hill to the cold clay field, with free intermixture by cultivation from year to year, will soon convert it into the richest loam; especially if some decaying vegetable matter be added to the mixture. On the other hand, for the soil which is

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Why then do they not exist in larger quantities in the soils? Does lime enter into the composition of living plants and animals? With what is it generally combined? What is meant by loamy soils? Are they generally found in nature? How may all soils be made *loamy*? How can a poor clay soil be converted into a productive loam?

too sandy and dry, the nearest bed of clay is a mine of wealth.

Hence one important item in all good husbandry is, so to distribute the sand, clay and lime, as to bring all the fields to the texture of fine, moist loam. Some authors describe four kinds of loam, viz :— sandy, gravelly, clayey and peaty; but it is evident that such a division only indicates that the sand, gravel or clay is the predominating ingredient.

PEATY SOILS.

Carbon and its compounds form the most prominent ingredients in all the soils of this class. They originate from growing vegetables, which accumulate in swamps and marshy places in a half-decayed state, sometimes to the depth of several feet. This mass of vegetable matter, by the overflowing of water, becomes more or less mixed with sand, clay, or other mineral ingredients ; and assumes a loose or compact state according as the sand or clay predominates.

Sometimes the vegetable matter settles into a compact mass of nearly pure carbon, fit for fuel, as in some of the peat marshes of Ireland. The peaty or carbonaceous soils are all capable of being brought to a high degree of fertility, by draining and proper cultivation. They should, indeed, rather be regarded as immense beds of vegetable manure, than as soils.

What constitutes an important item in all good husbandry ? How many kinds of loam are described by some writers, and what are they called ? Why are they so called ? What constistute the most important ingredient in all peaty soils ? From what do soils of this class originate ? Where are they chiefly found ? How do they sometimes become mixed with sand, clay, and other mineral ingredients ? What form does the vegetable matter sometimes assume, and for what is it then used ? How can peaty soils be rendered highly fertile ?

It is thus seen that siliceous, aluminous, calcareous and carbonaceous compounds form the basis of all soils; that either of them, alone, is incapable of supporting vegetation; but that all mixed in due proportion in the same soil, retaining a small per cent. of oxide of iron, potash, soda and ammonia, present the highest degree of fertility. Hence, as we have already said, the highest skill of the farmer consists in rapidly bringing about and maintaining such a mixture. From a neglect to do this, thousands of peat swamps are left with nothing but the frogs to croak over their almost inexhaustible stores of manure, while the negligent farmers are reaping scarcely the amount of their seed from the dry and gravelly ridges which surround them.

ORGANIC INGREDIENTS OF SOILS.

Although decaying vegetable matter, aside from that which forms peat, does not characterize any particular class of soils, yet it forms an ingredient in all cultivated soils, second in importance to no other. It is, indeed, during the progress of decomposition and decay in vegetable or organized matter, that several acids are formed, which, by uniting with the inorganic elements we have described, such as alumina, potassa, oxide of iron, &c., renders them soluble and fit to nourish the growing plant.

What substances form the basis of all soils? Is either of them alone capable of supporting vegetation? When do they present the highest degree of fertility? In what then does the highest skill of the farmer consist? What results from a neglect of this? Does decaying vegetable matter, aside from peat, characterize any particular class of soils? What constitutes an important ingredient in all cultivated soils? What substances are formed by the decay of vegetable matter? With what do they unite in the soil? What important quality does it impart to them?

All vegetable substances are composed ultimately of oxygen, hydrogen, carbon and nitrogen—the carbon alone forming, perhaps, 50 per cent. of their whole bulk. In the process of decomposition, these ultimate organic elements unite with each other in new proportions, forming a variety of new compounds, some of which are still but imperfectly understood. But the most important of these are water, a dark brown insoluble substance called humus by some, and geine by others, and which differs but little in composition from woody fibre; humic or geic acid, which differs from humus principally in being soluble in 2,500 times its weight of water, and by its uniting with earths, oxides or alkalies, to form salts.

A third compound is the crenic acid of Dr. C. T. Jackson, a substance of a yellow color, acid and astringent taste, and very soluble in water. It is composed of carbon 7, hydrogen 16, nitrogen 1 and oxygen 6. It has a strong attraction for earths and alkalies, forming soluble salts with lime, potash, soda, ammonia and oxide of iron. Hence its great importance in the soil consists in rendering these inorganic substances soluble, and thereby fitting them for absorption by the roots of living vegetables. This is probably the most important product of vegetable decomposition.

The apocrenic acid is formed by simply exposing the crenic acid to the action of the air. The proportions of carbon and nitrogen are increased, while

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Of what are all vegetable substances ultimately composed? How large a share of their bulk is carbon? What are the most important products of vegetable decomposition? In how much water is humic or geic acid soluble? With what does it unite and form salts? What are the qualities of crenic acid? Of what is it composed? For what has it a strong attraction? What makes it of great importance in the soil? What is the difference between the crenic acid and the apocrenic?

those of hydrogen and oxygen are diminished. This acid also forms salts with earths and alkalies, but they are less soluble in water than the crenates. The presence of alkalies in the soil facilitates the decay of vegetable matter, while most acids retard it.

Having in this chapter spoken briefly of the formation, classification and composition of soils, we shall, in the next, inquire into the composition of vegetables, and the sources from which they derive their ingredients.

CHAPTER IV.

Sect. 1. *Composition of Vegetables.*

We have already had occasion to state, that all vegetables are composed of oxygen, hydrogen, carbon and nitrogen, combined in various proportions in different parts of the plant. Besides these, which are called organic elements, all plants contain a small quantity of some one of the following alkalies, earths, oxides or simple bodies, viz: silica, alumina, potash, soda, lime, oxide of iron, magnesia and phosphorus. These frequently exist in the living plant in the form of humates or crenates, and are called *inorganic* elements of plants.

The oxygen and hydrogen in vegetables exist in large quantities in the form of water, while the carbon makes up a large share of their solid substance, and the nitrogen is found mostly in the flowers and fruit. The inorganic ingredients are found in all

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What effect do alkalies and acids have on vegetable matter in the soil? What simple substances enter into the composition of vegetables? With what are the inorganic elements generally combined? In what state is the oxygen and hydrogen? What parts of plants contain the most nitrogen? In what parts are the inorganic ingredients found most abundant?

parts of plants, to some extent; but in the grasses and grains they exist much more abundantly in the outer part of the stalks, and the coverings of the fruit or seed.

But to gain a proper knowledge of plants, we should pass from their ultimate ingredients to a study of their more important parts, or proximate principles.* Thus almost the entire value of the various species of grain depends on the maturity and perfection of their fruit—the cane on its sugar; the potato on its starch; the almond on its oil; and the medicinal plants on their acids, alkalies, or oils.

Wheat, rye, oats, corn and beans, are composed principally of albumen, starch and gluten. The first and the last contain large quantities of nitrogen, while the starch contains only carbon, hydrogen and oxygen. Sugar is also composed of carbon 12 parts, hydrogen 10, and oxygen 10. The oils are chiefly composed of carbon and hydrogen; while in the vegetable acids, oxygen, and in the alkalies, nitrogen is the predominating ingredient. All these proximate elements may be arranged in three classes, viz: acids, alkalies and neutrals.

ACIDS.

There are more than one hundred vegetable acids, very few of which, however, are of any importance

* By proximate principles, are meant vegetable ingredients which are themselves compound, i. e. made up of two or more simple or primary elements. Thus gluten, starch and sugar are proximate principles or elements, yet each of them contains the primary elements, oxygen, hydrogen, carbon, and the first nitrogen.

What are the proximate principles of plants? On what does the value of the various species of grain depend? Of what are wheat, rye, oats, corn, &c., principally composed? Does starch contain nitrogen? What is the composition of sugar? Of what are the oils chiefly composed? Into how many classes may these proximate elements be arranged? What are they called? How many vegetable acids are there?

either in agriculture or the arts. The principal worthy of notice are the oxalic acid, from the sorrel; tartaric, from wine dregs; malic, from apples; citric, from limes; acetic, from vinegar; tannic, from bitter barks; gallic, from nut-galls; and prussic, from the laurel.

All these contain a large quantity of oxygen, united with carbon and hydrogen, except the last named, which contains no oxygen, but in its place one proportion of nitrogen, and is excessively poisonous.

ALKALIES.

The vegetable alkalies are fewer in number than the acids, and have all been discovered by chemists since the commencement of the nineteenth century. They are nearly all of them medicinal, and highly poisonous; but are of very little practical utility in agriculture. They are all characterized, chemically, by containing a considerable quantity of nitrogen. The principal alkalies of this class are morphia, quinia, strychnia, emetia, veratria, nicotia, solanea, &c.

NEUTRALS.

The substances classed as intermediate, or neutral, are very numerous, and some of them important. They embrace the coloring matter of vegetables, which forms the basis of dyes; the fixed and volatile

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Which are most worthy of note? From what vegetables are they obtained? What ingredient does hydrocianic acid contain that does not generally exist in vegetable acids? When were the vegetable alkalies discovered? What are their qualities? Are they of any practical utility in agriculture? What simple substance seems to characterize their composition? Can you name the principal alkalies? Are the neutral ingredients of vegetables numerous or important? What substances are included in this class?

oils; the resins, gums, extractive matter; together with starch, sugar, gluten, &c., the composition of which we have already alluded to.

All these proximate elements of plants contain, in addition to the carbon, oxygen, hydrogen and nitrogen, of which they are chiefly composed, traces of earthy, alkaline and metallic substances. They are also exclusively the product of living plants, and cannot be formed in the laboratory of the chemist. Their ingredients are held together by a feeble affinity; and hence most of them soon enter into a state of decay or decomposition, when separated from the living plant, and exposed to warmth and air.

Sect. 2. *Sources from which Living Vegetables derive their Ingredients.*

It will be seen by our enumeration of organic and inorganic ingredients, that it embraces substances derived from the earth, the air and the water. Hence every living plant must look to all three of these sources for the materials for its growth and maturity.

Formerly it was an almost universal opinion that all vegetable ingredients were derived from the soil; but a knowledge of the fact that the leaves of growing plants absorb a considerable quantity of carbonic acid from the air, and retain its carbon, was sufficient to throw doubt on this opinion. Hence a variety of experiments were resorted to, for the purpose of determining both the amount of matter taken from the soil by the living plant, and the precise amount of carbon taken from the atmosphere. The result was

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What do they all contain besides their organic ingredients? Can they be formed by the chemist? What changes soon take place when they are exposed to warmth and air? Why are they so subject to change? From what sources do living plants derive their ingredients? What was formerly the prevailing opinion on this subject? What caused a change?

a clear demonstration that, while the inorganic ingredients, together with water and a small quantity of carbon, in the form of humic and crenic acids, were derived from the soil, much the larger share of the carbon which forms the solid part of plants, was derived from the carbonic acid contained in the air.

It seems, however, still to be doubted by some, whether the carbonic acid of the atmosphere is absorbed directly by the leaves, or is washed down by rains, dews, &c., into the soil, and absorbed by the roots. But this is a question of very little practical importance, as in either case the origin of the carbon is the same.

Water is doubtless the principal source of oxygen and hydrogen. It is constantly presented to the leaves in the form of vapor floating in the atmosphere, and dews; while it is always present holding in solution the soluble matters in the soil, for absorption by the roots.

Nitrogen, though existing in much less quantity than the other organic ingredients, is nevertheless present in all vegetables. And though it forms four-fifths of the atmosphere, yet vegetables seem to derive very little, if any from that source. It is now generally conceded that most of the nitrogen of plants is derived from *ammonia*—a gaseous substance composed of 14 parts of nitrogen and 3 of hydrogen. It is always present in the atmosphere, and is emitted abundantly by all decaying vegetable substances.

What ingredients do vegetables derive from the soil? What from the atmosphere? What difference of opinion still prevails in regard to the manner in which carbonic acid gas is taken up by plants? Is the question of any practical importance? What is the source of oxygen and hydrogen? In how many ways is water presented for the action of plants? Is nitrogen an ingredient in all vegetables? Do they derive it from the atmosphere? From what is it derived? What is the composition of ammonia? Where is it always present, and how is it formed?

Hence the earth, the water and the air, each contribute freely the materials necessary for the living plant. The first, by the disintegrating influence of air, water, heat and cold, gradually unlocks its inexhaustible stores of mineral or inorganic elements; these combine with the geic or humic and crenic acids of the decaying vegetable matters, forming soluble salts; which are dissolved by the water, and presented to the living roots for absorption and nourishment. While the last is ever holding in contact with the leaves and flowers its unfailing supply of carbon and nitrogen, from the carbonic acid and ammonia which it is every moment receiving—the first from the respiration of animals and combustion, and the latter from the decomposition or decay of vegetable and animal matters on the earth's surface.

And here we cannot refrain from alluding to one of the most beautiful illustrations of Divine wisdom presented in nature. Every fire kindled on the surface of the earth, and every animal that breathes, is constantly depriving the atmosphere of its oxygen and supplying it with carbonic acid; while the whole vegetable kingdom is as constantly appropriating the carbon of this carbonic acid to itself, and emitting again the oxygen—thus forever preserving the equilibrium, the harmony, and the activity of nature's works. Of the powers of the living plant to appropriate to itself the various elements of which it is composed, or, in other words, of the theories of assimilation, we shall speak more particularly in another chapter.

What agents are constantly acting on the inorganic ingredients of the soil? With what do the mineral ingredients combine to form salts? By what then are they dissolved? From what sources does the atmosphere receive its carbonic acid gas? From what its ammonia? How is the Divine wisdom beautifully illustrated?

CHAPTER V.

The Means possessed by man for fertilizing the Soil, and adapting it for the growth of any Crop which he may desire.

Although the great Architect of Nature doomed man to obtain his bread by the sweat of his brow, He, at the same time, spread before, beneath and around him, in rich abundance, everything which could contribute to render his enlightened labor productive. Enlightened labor, I say; for labor applied without knowledge, is very much like the peevish philosopher's physician, who in the treatment of disease, struck blindfolded and hit the patient or the disease, as chance or accident directed. So the farmer, blinded by ignorance of the composition of both the soil and the vegetables he wishes to grow therefrom, necessarily makes the results of his labor altogether accidental. The means possessed by man for rendering the soil productive, may be arranged under the three following heads, viz: 1st, Mechanical operations on the soil itself. 2d, The addition of such inorganic substances as are deficient in the soil which we wish to cultivate. 3d, The addition of vegetable and animal substances, generally in a state of decay, and called manures. The first division includes the important processes of ditch-

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What is labor without knowledge like? When are the results of the farmer's labor altogether accidental? Does man possess any means for rendering the soil more productive? Under how many heads may these be arranged? What are they? What does the first division include?

ing, draining, leveling, ploughing, harrowing, &c. And though all these processes have been carried on by farmers from generation to generation, until it would seem that every child must understand them, yet a few observations on each will not be amiss in an elementary work like this.

DITCHING AND DRAINING.

All wet lands, whether they are low and marshy or elevated and filled with springs, should be drained to render them fit for cultivation. This is an important proposition, and should never be neglected by the agriculturist. Wet soils are generally aluminous, and when drained and properly cultivated, they assume the most fertile character.

Draining is accomplished by ditches, dug in such a manner as to carry the water from its source in the springs or marshes, to some stream or rill formed by nature to convey it on to the rivers, &c. The depth of a ditch for draining should always be such as to reach through the soil, and at least twelve inches into the subsoil below—making the whole from two to four feet deep.

Ditches for draining should *always* be cut in such direction as will cut off the springs which supply a field or marsh, at their source, before the water issuing from them becomes diffused through the soil. Neglect of this rule often prevents two-thirds of the benefits expected from draining. We often see ditches cut directly through the lowest part of a field or marsh, extending from one principal spring to the

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What lands should be drained? What kind of soils are most apt to be too wet? How may they be made most fertile? How is draining accomplished? How deep should the ditches be dug? In what direction should they be dug? At what point should they cut off the springs? Is this rule always followed? If not, what is the consequence? How do we often see ditches cut?

nearest natural outlet. Now, such a ditch will do some good; and if there is but one spring to be drained, it will answer the whole purpose. But if, as is *generally* the case, there are several springs issuing from the same direction, perhaps from the side or base of a hill or ridge of land, it is plain that all these, except the one to which the ditch directly leads, must pass through a part of a field before reaching the ditch, and thereby exert all the evil influence on the soil as though no ditch was there.

In all such cases, to follow the rule which we have laid down, would be to cut a ditch directly through the springs, *parallel* with the hill or ridge of land; and, if need be, another through the lowest part of the field, from the first to the nearest outlet for the water. Or if the land to be drained is a marsh, almost surrounded by hills, a deep ditch should be dug directly through the centre, for a main outlet; and another entirely around the circumference of the marsh, in such a manner as to cut off all springs from the edges, and emptying itself into the central ditch or outlet. In this manner, almost any swamp or marsh may be effectually drained and rendered fit for cultivation.

Very deep ditches, and those designed to contain considerable water, should be left open and occasionally cleaned out. But all others are rendered most convenient and durable, by filling them half full or more with rounded stones, in such a manner as to afford space for the water to drain through; covering

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When do they answer the purpose intended? When do they fail, and why? If you have a piece of ground made wet by several springs issuing from the side or base of a hill, how many ditches would our rule cause us to cut, and in what direction? What if the land be a marsh almost surrounded by hills? What should be done to very deep ditches that are designed to contain much water? How should all others be treated? How should ditches be filled?

the stones with a layer of straw, and then filling the remaining space with dirt, even with the surface of the surrounding soil. In this way the drain remains quite permanent, and still the surface of the field is left unbroken, to be ploughed over without obstruction.

LEVELING.

This process, though less important than the preceding, is still deserving of more attention than it receives. Leveling cultivated grounds with the roller, to prepare them for meadows, is well understood, and often practiced. It is most beneficial on light, sandy soils. It should also be remarked, that soils on the sides of steep hills are better adapted to grazing than tillage, as every shower of rain is continually washing the most valuable ingredients of such soils down into the valleys below, if they are kept loose by ploughing.

PLOUGHING.

Perhaps no part of husbandry is more familiar than ploughing, and no part, as a general rule, more imperfectly done. The farmers of this country, anxious to gain possession of extensive farms, generally occupy more land than they can command means to cultivate in a proper manner. The consequence is, that the ploughing, like everything else, is done in a hurry, and therefore only half done. The best fields are ploughed only once, and the hardest twice; and what is not cut up, is said to be covered up; and,

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What advantage is there in having the ditches covered in this manner? What are meadow grounds often leveled with? What soils are most benefited by the roller? For what are steep hill sides best adapted? Why? Do farmers in this country occupy too much or too little land? What is the consequence on the process of ploughing?

hence, ready for the seed. This is all wrong, and, in fact, ruinous both to the farm and the farmer.

The invariable rule should be, to cultivate no more land than can be done well; and in ploughing, to *repeat* the *process* until the soil, to the depth of a full, deep furrow, is reduced to a fine mellow texture, whether it require the process to be repeated *ten* times or only once. The furrow should also be cut deep enough to turn up and thoroughly expose the lower part of the soil, that mineral ingredients, capable of supplying the inorganic elements of plants, may be exposed to the action of the air, moisture, &c.; and thus fitted for the action of the roots of living vegetables. Such ploughing, continued for a few years, with due care in the addition of proper substances as manures, will convert almost any soil into a fine mellow loam; which is the state so desirable to every agriculturist.

The advantages of having the soil in such a condition are, that it affords the greatest facility for the extension of the young roots, and most readily yields to them its nourishing qualities; that it more readily absorbs the water which falls on its surface, and thereby prevents it from injuring the tender plants; and it also becomes fit for cultivation much earlier in the spring than a soil that has been left in a hard and compact state; and, finally, its loose, porous texture prevents it from becoming baked hard and dry in the season of drought, and it allows the moisture from the sub-soil below to rise through it, to

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What effect does this have both on the farm and farmer? What invariable rule should be followed both in regard to the quantity of land and the amount of ploughing? How deep should the furrow be cut? Why so deep? What effect will such ploughing, with a due addition of manure, have on the soil? What are the advantages of having the soil in such a condition? Why does it not suffer so much from droughts?

sustain vegetation on its surface. All soils should be ploughed from six to twelve inches deep, for the roots of many plants naturally penetrate even deeper than this.

SUB-SOIL PLOUGHING.

By sub-soil ploughing, we mean stirring or breaking up the under soil, several inches below the ordinary surface-soil. This is done by a machine called a sub-soil plough, which is so contrived that at the same time it turns over the surface-soil in the ordinary way, it tears up and mellows the sub-soil at the bottom of the furrow. This kind of ploughing is of great benefit on all tenacious and heavy soils, and should be occasionally resorted to on all soils.

It is not only beneficial to stir up and render more porous the sub-soil, but it is often of the greatest benefit on lands which have been long cultivated, to cut the furrow so deep as to bring the sub-soil to the surface, and thereby expose it thoroughly to the action of the weather and vegetation. This is rendered necessary from the fact, that during many years of cultivation the water has been gradually dissolving the soluble parts of the surface-soil and carrying them down into the sub-soil. Hence we sometimes arrive at the point where we find the sub-soil richer in all those ingredients required for vegetation than the soil on the surface.

How deep should all soils be ploughed? Why? What is meant by sub-soil ploughing? How is this done? How is the sub-soil plough constructed? What class of soils are most benefited by this kind of ploughing? What kind of ploughing is beneficial on soils that have been long cultivated? What object is gained by this? What renders such ploughing necessary? Do we ever find the sub-soil richer than the surface?

HARROWING.

Not only should the soil be ploughed until it is thoroughly and deeply pulverized; but its surface should be still more finely pulverized by the frequent and thorough application of the harrow or drag. The use of this instrument is also of great value for covering the seed when sown, and for leveling the unevenness of the surface.

The addition of Inorganic Substances as means of Fertilizing the Soil.

It will be remembered, that by inorganic substances in agriculture, we mean all those earths, alkalies and metallic oxides, which either enter into the composition of vegetables, serving for nourishment, or which promote their growth indirectly, by rendering the humus or geine of the soil more soluble, by neutralizing the excess of acids, by rendering the soil more loamy, or by absorbing and retaining, in contact with the roots, those gaseous substances which would otherwise escape and be lost.

The principal substances of this kind are—1st, siliceous earth, or sand and gravel; 2d, aluminous earth or clay; 3d, calcareous earth, or carbonates, phosphates, and sulphates of lime; 4th, magnesia and manganese; 5th, alkalies—as potassa, soda and ammonia; 6th, oxide of iron.

Of the nature and origin of all these substances, we have already treated in the preceding chapters. They are all furnished in abundance, ready for the preparing and applying hand of the farmer. The

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How can the surface of the soil be more finely pulverized than by the plough? What other uses has the harrow besides finely pulverizing the soil? What do we mean by inorganic substances in agriculture? What are the principal inorganic substances that may be used for fertilizing the soil? Are these substances all furnished abundantly in nature?

first is found in every sand hill; the second in every clay bed; the third in the immense beds and ridges of limestone rocks, shells, bones, &c.; the fourth generally in connection with the third; the fifth in the granite, gneiss and mica rocks, in ashes, common salt, sea weeds, and decaying animal matters; and the sixth in almost all clays. Of the preparation of these substances, and their applicability to particular soils, we shall treat in the next chapter.

Vegetable and Animal Substances as Fertilizers of the Soil.

It has already been stated, that the presence of more or less vegetable matter, in a state of decay, is necessary in every cultivated soil. We have also stated its nature and uses in the state in which it is generally found. It remains, however, to be shown, from what sources and in what state the agriculturist can obtain the supply which he needs.

The first and chief supply of these substances comes in the refuse matters which accumulate in every farmer's barn-yard. These are made up of the stalks and straw derived from the harvest field, and the *excretions* of animals or farm stock. And if due economy and diligence is used in collecting, preparing and applying everything from this source, it is generally sufficient for the farmer's supply.

But there are other sources which should never be neglected, such as the chip-yard, the peat and muck swamps, sea-weeds, refuse wool and gleanings

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Where may each generally be found? What is the next subject treated of? What is necessary in every cultivated soil? What is the first and chief source of decaying vegetable and animal matter for the farmer's use? Of what is this supply composed? What is necessary to render the supply from this source sufficient for the farmer's use? What other sources should not be neglected?

of factories, hair, horns, hoofs, feathers, and bones of animals; the contents of privies, &c. Indeed, there is nothing of a vegetable or animal nature, from the half-decayed chip in the door-yard, to the bones that lie bleaching in the corners of the fields, which the skillful farmer may not convert into rich materials for fertilizing his soil. These substances are presented to the agriculturist in every state or condition, from fresh and fully organized vegetable and animal matter to that of the most complete decomposition or decay. And their value depends almost entirely on the manner in which they are prepared and applied.

The most valuable ingredients in vegetable and animal manures, are, humus, geine, humic and crenic acids, the soluble salts contained in the solid and liquid excretions of animals, and the gaseous substances formed during animal and vegetable decomposition—as carbonic acid, ammonia, carburetted hydrogen, &c. These gases being volatile, are, like the liquid excretions of animals, mostly suffered to escape by the manner in which they are kept, and are, hence, lost to the agriculturist, though they are decidedly the richest and most valuable fertilizers of the soil which we possess.

It is these liquid and volatile matters which contain by far the largest proportion of nitrogen, a substance essential to the formation of some of the most nutritive ingredients in the various grains, and hence of the greatest value in the growth of that class of vegetables. The almost total neglect of these substances in our country is, perhaps, a greater loss to the agri-

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In what state are these substances presented to the farmer? On what will their value depend? What are the most valuable ingredients in vegetable and animal manures? What valuable ingredients are generally suffered to escape or be lost by the manner in which the manure is kept? What simple element of great value is contained in the liquid and volatile ingredients? To what particular class of vegetables is this ingredient important?

culturist every year, than is occasioned by all the diseases and insects which ever attack the products of the farm.

Experience and observation both show, that the two greatest errors in American agriculture, are a disposition to cultivate too much land, and bad management or total neglect of manures; for it is as easily demonstrable, that with an accurate knowledge of the soil, and a judicious preparation and application of organic and inorganic manures,* *any* desirable crop can be raised on any given soil, as any problem in mathematics.

CHAPTER VI.

The Preparation of Manures, and their Adaptation to Particular Soils.

The preparation of manures is one of the most important operations of the farmer; and one, too, requiring a good knowledge of chemical principles, particularly in regard to the laws of combination and affinity. In treating the subject, we shall follow the same arrangement adopted in the last chapter.

* The term *manure* is applied to any substance used to promote the growth of vegetables.

What are the two great errors in American agriculture? How may any given crop be raised on any cultivated soil? Of what does chapter sixth treat? What constitutes one of the important operations of the farmer? Of what does it require a good knowledge? What is meant by the term *manure* in agriculture?

Sect. 1. *Inorganic Substances used as Manure.*

SAND OR GRAVEL.

This substance exists abundantly in almost every country, and is found in various forms, from very fine sand to pebble stones or coarse gravel. It is chiefly composed of silex or silica, and is admirably adapted for changing the composition and texture of cold clay soils. For this purpose a layer of it should be spread over the field, and then thoroughly mixed with the clay by the plough and harrow. In this way it not only greatly diminishes the cold and tenacious qualities of the clay, and brings it nearer to the character of moist loam, but it also changes the electrical condition of the soil, and enters to some extent as an ingredient into many living plants. Whether it should be added in the form of fine sand or coarse gravel, will depend on the precise object to be accomplished. If we wish to produce an immediate effect on the first crop, fine sand should be used ; but if permanency of effect is the leading object, it should be coarse gravel. A mixture of both is, however, much preferable to either alone, in almost every instance.

Fine sand is also one of the best applications to peat swamps and meadows, after draining. Such soils are too friable, and almost wholly carbonaceous. Hence the value of adding fine sand or silex.

When we reflect how nearly together nature has almost universally placed the sand hills, the clay

For what is sand or gravel well adapted ? How can it be used for this purpose ? What changes does it effect when properly applied to a cold clay soil ? Does it ever enter into the composition of living plants? When should we use fine sand ? What difference is there in the effect between fine sand and coarse gravel ? What form is generally preferable ? To what other soils is fine sand particularly applicable ? What principal defect exists in peaty soils ?

fields and the swamps, and how valuable to the agriculturist is the modifying influence of each, when mixed with the others, we are surprised at their almost total neglect.

CLAY, MARL, &c.

The value of clay, or aluminous earth, for improving soils of a light, sandy nature, is beyond estimation. The composition of common blue clay is as follows—analyzed by Prof. Hitchcock, of Massachusetts—viz :

Water organic matter,	4.00
Silica,	61.52
Alumina,	20.50
Protoxide of iron,	9.82
Oxide of Manganese,	.56
Lime,	.56
Magnesia,	.44
Sulphur and loss,	3.22

It will be seen by this analysis, that clay contains, beside its alumina, a large quantity of oxide of iron, some sulphur and lime ; and in many specimens of clay the proportion of lime is greatly increased. Hence, by the addition of clay to dry, sandy or peaty soils, we not only improve their texture by the adhesive qualities of the alumina, thereby making them more retentive of moisture and organic manures ; but in the lime, sulphur and iron, we have other highly valuable materials.

The sulphur and oxide of iron, on free exposure, soon form persulphate of iron, containing more or

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What kind of soils are improved by the application of aluminous earth or clay ? What is generally the composition of common blue clay ? Which of the ingredients are particularly valuable ? In what way do they improve light sandy soils ? What changes do sulphur and oxide of iron undergo when freely exposed to the air ?

less free sulphuric acid, which, if lime is present, unites with it, forming the much used sulphate of lime or plaster. Again, the protoxide of iron, in taking another proportion of oxygen to form the peroxide, hastens the decay of vegetable matter, and thereby increases the formation of humic and crenic acids.

Clay, marl, and the sulphate of lime, which we have seen is sometimes formed from the ingredients contained in clay, all possess the property of absorbing and retaining many gases, particularly ammonia, carbonic acid and sulphuretted hydrogen, all of which are exceedingly valuable for increasing the growth of vegetables, when retained in contact with their roots in the soil.

Hence the addition of clay to sandy and dry peaty soils, improves their texture by rendering them more retentive and tenacious; increases their stock of earthy and metallic ingredients; hastens the decomposition of vegetable matters; and aids in the absorption and retention of gaseous matters, which would otherwise escape. Surely all these advantages demand for this subject more attention than it has yet received among practical agriculturists.

The best mode of applying clay or marl, is to spread it over the sand and peat fields in the fall, and allow it to lie exposed to the frost and rains until spring, when it should be thoroughly mixed with the soil, by ploughing, &c. Alumina, the charac-

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If free sulphuric acid is formed, with what does it unite, and what is the compound called? What effect does protoxide of iron have on vegetable matter in the soil? What valuable property do clay, marl, and sulphate of lime possess? What valuable gases do they absorb? What four important benefits are derived from the application of clay to dry, sandy and peaty soils? What is the best mode of applying it? How large a proportion of all cultivated soils should consist of alumina?

teristic ingredient in clay, should form at least ten or twelve per cent. of every cultivated soil.

CALCAREOUS SUBSTANCES.

The principal articles of this class are carbonate, phosphate, and sulphate of lime. All these have been long known, and used as manures, in Europe; and yet, perhaps, the operation of no substances has elicited more controversy among farmers than these. Some have declared them injurious, and others highly beneficial, a contradiction which doubtless arises from ignorance not only of the mode of their action, but of the composition of the soil to which they were applied.

CARBONATE OF LIME.

This substance, generally known by the names of limestone, air-slacked lime, chalk, shells, &c., is composed of carbonic acid and lime. It is prepared for use, either by pulverizing the limestone, shells, &c., or by burning them until the carbonic acid is driven off, and the oxide of calcium, or quick lime, as it is termed, is suffered to slack or fall to pieces by exposure to the air; in which state it is partially re-converted into a carbonate. In this state it is added to such soils as are deficient in lime, and at the same time contain an abundance of insoluble or half-decayed vegetable and animal substances, and with the most beneficial results.

What calcareous substances are used as manures? Where have they long been used? What has given rise to contradictory opinions in regard to their value? By what names is carbonate of lime known? What is its composition? How is it prepared for use? When it is burned what changes does it undergo? Into what is it partially re-converted by exposure to the air? To what kind of soils is it applied with great benefit?

On such soils, the carbonate of lime acts in two ways, viz: 1st. Its acid displaces the silicic from the insoluble silicates of potash, soda, magnesia, &c., forming with them soluble carbonates, fit for absorption by the living roots. 2d. Its lime acts directly on the insoluble humus or geine, converting it into humic and crenic acids; thereby directly increasing the food for growing vegetables. The carbonate of lime not only thus increases the food of plants, but it also improves the texture of both the light and sandy, and the cold, clayey soils—it being more tenacious than the first, and less so than the last.

Lime, however, when added in excess to any soil containing but a small quantity of insoluble vegetable matter or humus, instead of acting beneficially, directly injures its fertility, at least for a time. In such a case, the lime, instead of converting the humus into humic or crenic acids, forms with it an insoluble compound, and thereby deprives the living plant of the small amount of nourishment which it would otherwise have derived from this source. This fact will probably afford an explanation of the directly contradictory opinions entertained concerning the value of lime as a manure.

The invariable rule in regard to the use of lime, should be, that it does not already exist abundantly in the soil, and that there is *present* an *abundance* of *vegetable* matter on which it may act. Lime is deficient in much the larger portion of the soils in this country, although limestone rocks exist in great abundance. Hence our farmers, in most places,

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In how many ways does carbonate of lime act on the soil? Can you explain the first? What is the second? What effect does it produce besides increasing the quantity of food for plants? What effect does lime have on a soil deficient in vegetable matter? Why is it then injurious? What should constitute an invariable rule in regard to the application of lime as a manure? Is lime deficient in most of the soils of this country?

need only to be sure that their fields are well supplied with decaying vegetable matter, such as chip-dung, decaying roots, leaves, &c., or coarse barn-yard manure, to insure all the highly beneficial effects of this substance.

Keeping these simple rules in view, lime may be added to cultivated soils in quantities varying from eight to fifteen bushels per acre, if air-slacked, or if ground or pulverized, one quarter more, with as much certainty of benefit as any other kind of manure.

PHOSPHATE OF LIME.

This substance is composed of phosphoric acid and lime. It is obtained principally from bones, horns, hoofs, and animal excretions. It is an exceedingly valuable manure, acting on soils and vegetation in a mannar very similar to the carbonate, of which we have just spoken. It, however, possesses this decided advantage—its acid itself acts as an essential ingredient in many valuable crops.

Phosphate of lime also forms a prominent ingredient in guano, a highly valuable manure obtained in large quantities from the islands in the Southern Ocean. It consists of the excretions of birds, which resort to those islands in great numbers at certain seasons. It contains about 25 per cent. of the phosphate of lime and magnesia, and is becoming extensively introduced to the notice of agriculturists.

What then is the principal precaution necessary in its application? How much may be applied on an acre? Of what is phosphate of lime composed? How does it act on the soil? What decided advantage does it possess over the carbonate? What constitutes a valuable ingredient in guano? Of what does guano consist? How large a proportion of phosphate of lime and magnesia does it contain?

The great value of phosphoric acid as an ingredient in some of our most valuable crops, renders every source and combination of it of much interest to the farmer. Hence we ought not to pass over the phosphatic minerals described in the geological survey of this State. In the first number of the American Quarterly Journal of Agriculture and Science, pages 60 and 61, three localities are mentioned which might be made to furnish more or less of the phosphate of lime for agricultural purposes. The first of these is eight or ten miles west of Port Kent, on Hogback Mountain, at the iron ore bed of Messrs. Thomlinson & McDonald; the second is at the Sandford ore bed, in Moria or Westport; and the third is at Crown Point; but it is yet uncertain whether any of these will yield the substance in sufficient quantity to render them extensively useful.

Dried bones have hitherto constituted the chief reliance of the agriculturist for the phosphate of lime. They are prepared by grinding or pulverizing, and applied in the same manner as the sulphate of lime or gypsum.

SULPHATE OF LIME, OR GYPSUM, OR PLASTER.

This substance, by whatever name it may be called, is composed of sulphuric acid, a substance known by the common name of oil of vitriol, and lime. It is found in great abundance, forming extensive strata

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What makes phosphoric acid of great value to the agriculturist? Are there any localities of phosphate of lime found native in this State? Can they afford it in sufficient quantities to be valuable in agriculture? Where are the localities alluded to? What has hitherto constituted the chief resource of the agriculturist for phosphate of lime? How are they prepared and applied? Of what is sulphate of lime composed? By what other names is it known? What is the common name for sulphuric acid? In what condition is sulphate of lime found in great abundance?

of rocks in many countries. These rocks are broken to pieces and ground, to prepare it for use. In this state it is sown over the fields of grass and grain, and applied on hills of hoed crops.

Its mode of action, and consequently its utility, have been long a subject of controversy. It does not afford food for plants, neither is it readily decomposed so as to act on decaying vegetable matter and silicates, like the carbonate. And hence it has very generally been regarded as a simple stimulant to quicken the vital action of plants. It possesses, in a high degree, the property of absorbing gases; and hence, Prof. Liebig has attributed its whole benefit as a manure to its power of absorbing ammonia from the air, and keeping it in contact with the roots of vegetables.

Experience has, however, demonstrated that it is not equally beneficial on all soils, or on all crops growing on the same soil, as we should suppose it would be, if its influence depended entirely on its absorption of ammonia. Hence Liebig's theory has been objected to by some as unsatisfactory.

The sulphate of lime or plaster proves most beneficial on alluvial and light sandy soils, and is scarcely felt on those of a cold, clayey nature. It seems also more beneficial when applied to corn, clover, peas, potatoes, cabbages, &c., than any other vegetables or grains. On clover and grass fields, it is sown broad cast, generally in the month of May. On corn, and other hoed crops, it is applied directly

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How is it prepared for use? In what way is it used? Is its mode of action well understood? How has it generally been regarded? What property does it possess in a high degree? To what did Liebig attribute all its value? Is it equally beneficial on all soils? or for all crops on the same soil? On what soils is it most applicable? What crops are most benefited by it? How is it applied to grass fields? How and at what time is it applied to hoed crops?

to the hills about the time of hoeing, in the quantity of one spoonful to a hill.

ALKALINE MANURES.

The principal substances worthy of notice under this head, are potassa or potash, soda, and ammonia. All these substances enter into the composition of almost all vegetables, and hence are of the first importance as ingredients of every cultivated soil. They are generally found combined with some acid, and the first two not only enter as ingredients into the composition of vegetables, but they, like lime, aid in decomposing and rendering soluble the organic matters with which they come in contact; while the latter furnishes to plants a great share of their nitrogen.

POTASH OR OXIDE OF POTASSIUM.

The nature and composition of this substance has already been described. It is contained in union with silicic, sulphuric or carbonic acid, in all soils which have not been already exhausted by cultivation. It is furnished in considerable abundance by all aluminous, granite and volcanic formations. The chief resource of the agriculturist for potash, as a manure, is the ashes of wood; and of this, every prudent farmer may save from his own fires a valuable quantity every year.

The composition, and consequently the value of ash, depends much on the kind of wood from which

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In what quantity? What are the principal alkaline substances used as manures? Why are these substances important as ingredients in cultivated soils? What valuable purpose do they serve besides furnishing food for plants? What is the composition of potash? With what is it combined in all soils? What kind of rocks afford it in abundance? What constitutes the chief resource of the agriculturist for potash? On what does the value of ash depend?

it is obtained. The soluble part of ash is composed of carbonate, sulphate and muriate of potash and soda; the insoluble portion, of silicate of potash and carbonate and phosphate of lime, magnesia and manganese, with a trace of oxide of iron.

It will be seen that all these ingredients are highly valuable additions to the soil. The silicate of potash forms a prominent ingredient in the sheath or outer covering of grasses and grains, while the phosphates are equally important ingredients in other parts of grain, especially of the fruit or berry of wheat. Indeed, the ash of the various grains grown in this country, separate from the straw, contains from 40 to 50 per cent. of phosphoric acid, and from 19 to 37 per cent. of potash and soda. Hence repeated removals of these crops from the same soil, without any return, very rapidly exhaust it of this alkali; and hence the great value of frequently sowing all grass and grain lands over with ash.

From five to fifteen bushels of unleached ash may be sown on an acre, in the same manner as plaster; and on corn it may be applied to the hill. Leached ash is mostly deprived of its soluble salts of soda and potash; but the silicates, phosphates and carbonates of lime, potash and magnesia, are still very valuable, both as ingredients of plants, and as acting on the humus and organic matters in the soil, in the

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What is the composition of the soluble part of ash? What the insoluble? What forms a prominent ingredient in the sheath or outer covering of the grasses and grains? Into what parts of the crops do the phosphates enter as necessary ingredients? How large a proportion of the ash of wheat, oats, &c., is composed of phosphoric acid and potash? What effect is produced by repeated removals of the same crop from the same soil? How much unleached ash may be applied to the acre of grass or grain land? How may it be applied to the corn crop? What is the difference between leached and unleached ash? What renders leached ash still valuable as a manure?

same manner as the salts of lime, to which we have already alluded.

SODA.

This substance exists in the soil in much less quantities than potash. It enters into the composition of very few rocks, being found principally in serpentine and volcanic formations. Its action on vegetation is in all respects similar to potash, though much less necessary.

The chief resource of the farmer, is in the chloride of sodium or common salt, a substance widely diffused throughout nature, and existing in great abundance in sea-water, and in solid masses beneath the surface of the earth in many countries. It is composed of chlorine and sodium, one proportion of each. But when it is dissolved in water, the chlorine takes hydrogen, and is converted into muriatic acid; and the sodium unites with one proportion of oxygen, to form soda. Hence, in solution, we have muriate of soda.

It may be applied to soils, particularly of a sandy nature, in quantities of from six to fifteen bushels per acre, with great benefit; and if the salt is sown on the field some time before the seed is sown, much larger quantities may be used without danger of bad effects. But too much salt applied directly to any crop will destroy it. Perhaps the best mode of using

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In what natural formations do we find soda? What substance does it resemble in its action on vegetation? What constitutes the chief supply of soda for agricultural purposes? What is the proper name of common salt? Of what is it composed? Where does it exist in great abundance? What change does it undergo when dissolved in water? To what soils may it be applied with benefit? How much may be applied per acre? Under what circumstances may we apply more with safety? Is there any danger of applying too much? What is the best mode of using salt?

salt, is to mix or compost it with peat, stable manure, or lime. The best proportions for use with manure are, one bushel of salt to six or eight tons of stable manure. If it is to be used for wheat, on which it proves of great value, the manure may be spread on the soil as usual, and the salt sown with the seed.

When mixed with lime, two parts of the latter should be mixed with one of salt, and allowed to remain several weeks before it is used. In this case the salt is decomposed and muriate of lime is formed, while the caustic soda is left free to act powerfully on the insoluble vegetable matter which may be present in the soil to which it is applied. Mixed with *soot*, in equal parts, salt has a powerful influence on root crops, such as beets, carrots and potatoes, in some instances doubling the product per acre.

A small quantity of salt mixed with the soil in each hill of corn is a pretty sure preventive against the attacks of wire and cut worms; and, indeed, it is quite probable that one of the most valuable qualities of salt, when applied to the soil, will be found in its destructive action on insects of all kinds.

AMMONIA.

We have already stated the composition of this alkali to be 14 of nitrogen and 3 of hydrogen. In its free state it is gaseous, with a pungent smell, and strong alkaline taste. It is absorbed in large quantities by water, charcoal, gypsum or plaster,

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What is the best proportion for mixing with stable manure? On what crop is it particularly beneficial? How may it be applied to wheat, and in what quantities? In what proportion may it be mixed with lime and what precaution is necessary? What changes take place in this mixture? To what crops is it very beneficial when mixed with soot? What will prevent attacks of wire and cut worms? What is the composition of ammonia? What are its sensible qualities? By what is it absorbed?

dry clay, &c. It may be detected in the juices of all plants, its principal use being to supply them with nitrogen. It is always present in the atmosphere in sufficient quantities to supply the wants of vegetation. It also exists in the soil, to which it is constantly brought by rains and such mineral substances as absorb gases.

Its principal supply for agricultural purposes is in animal and vegetable manures. Hence it is unnecessary to say much of it, except in connection with the preparation and use of those substances. It unites readily with most acids, but is never used in a separate state as a manure.

Sect. 2. *Organic or Vegetable and Animal Manures.*

The composition and qualities of vegetable substances mixed with soils, we have already mentioned in Chapter III., in reference to the organic ingredients of soils. The most important products arising from vegetable and animal manures, such as the humus or geine, humic and crenic acids, carbonic acid, and ammonia, from vegetable matter; and phosphates, carbonates, sulphates, muriates, and urates of lime, potash, soda, and ammonia, from animal excretions, have also all been described, both in regard to their composition and mode of action. Hence it remains to describe their mode of preparation and application.

Two things should always be kept in view in the preparation of this class of manures. The first is to

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In what part of plants may it be detected? What is its principal use? Where is it always present? What affords the principal supply for agricultural purposes? With what does it readily unite? Is it ever used in a separate state as a manure? What are the most important products in vegetable manures? What in animal manures? What is the first thing to be kept in view in the preparation of this kind of manures?

effect a complete decomposition of the organic matter, whether vegetable or animal, and its conversion into *soluble salts* and gaseous substances; and the second, to retain these until they can be applied to the soil in a manner the most effectual for promoting the growth of crops.

The first of these is effected by a species of fermentation, induced by exposing the organized matter to a certain degree of warmth and moisture; and the second by mixing with the fermenting materials some substance which will absorb the valuable gases as fast as formed, and by sheltering the whole from rains, and everything calculated to wash away the soluble matters formed.

The refuse matters which accumulate in every farmer's barn-yard, constitute his principal dependence for manure. And, as a general rule, the *quantity* and *quality* of his crops will be in direct proportion to the skill and prudence which he exhibits in the preparation and application of this kind of manure. If he removes his crops from his fields from year to year, without returning anything in the form of manure, his soil soon becomes exhausted of vegetable matter, and those inorganic substances which we have described as necessary to vegetation, and his fields will be left unproductive. Or if he leaves all his manure scattered over his barn-yard, with the ammonia and other gaseous matters to escape entirely, and the soluble parts to be washed away by rains and lost, with all the liquid excretions of ani-

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What is the second? How is the first object accomplished? How is the second? What constitutes the farmer's principal dependence for manure? On what will the quantity and quality of his crops depend? What will be the effect of removing his crops from year to year without adding any manure to his soil? What effect will such a course have on the productiveness of the soil? What, if he leaves his manure scattered over the barn-yard, exposed to the rain, &c.?

mals, and then applies the solid matter which remains, which is composed almost wholly of geine or carbonaceous matter, to his fields, he may continue to obtain abundant crops of *stalks* or *straw*, but will assuredly fail to obtain a good yield of corn or grain of any kind. For in this instance the ammonia, which yields nitrogen; the phosphoric acid, the potash, and other alkalies, which are particularly necessary to the full development of all the *grains* and grasses, are almost entirely lost, while the straw, which is composed of a very large proportion of carbon, is supplied.

To prevent so great a waste of valuable matter, many agriculturists have adopted the plan of gathering the refuse matter of the barn-yard, including the solid excretions of animals, into one bed, through which are scattered several layers of swamp muck, or leached ash, or old plaster, or air-slacked lime, and the whole covered with muck or common earth. A degree of fermentation soon ensues throughout the mass—the vegetable matter is converted into humus, and humic and crenic acids, while the ammonia, carbonic acid, and other gaseous substances, are mostly absorbed and retained by the muck, and other earthy or alkaline materials scattered through the mass; and if the whole is sheltered from rains, it becomes in a few weeks or months a mass of fine compost or manure, containing a rich supply of those ingredients which add so much to the fertility of any soil.

Of what is the solid matter which remains chiefly composed? What effect will such manure have on the crop? Why will it promote the growth of stalks or straw, and not the grain or fruit? How do some farmers prepare their manures? What change takes place in such a heap? What absorbs the ammonia and other gases? What is the result in a few weeks or months?

This process is called composting, and the product compost, to distinguish it from other manure. It is a very great improvement over the ordinary method of permitting everything to lie scattered over the barn-yard, to be washed away and wasted, on account of its better quality, and much greater quantity, caused by the addition of earth, muck, &c.

But this method is highly objectionable on account of its making no provision for saving the *urine*, or liquid excretion of the animals, which of all substances is perhaps the *richest* and most *valuable* for promoting the growth of farm produce. It is composed almost entirely of water highly charged with soluble phosphates, carbonates, and sulphates of *ammonia*, soda, potash and lime, which we have already seen are the most valuable fertilizing salts which we possess. How, then, shall the farmer save this valuable material, and what course shall he adopt to convert all the refuse matter, not only of the barn-yard, but of the whole farm, into the most valuable manure for his soil? The following is undoubtedly the best and most economical mode which has yet been devised.

1st. Let good stables be prepared for all the farm stock, as well for the comfort and safety of the animals, and cheapness of keeping, as for the saving of both the liquid and solid excretions for manure.

2d. Let ample cellars be prepared, extending underneath the whole of the stables, with troughs so fixed underneath the floor that all the liquid excretions shall be conducted into one or more cisterns

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What is this mode of preparing manure called? What are the advantages of this method? To what strong objection is it liable? What is the most valuable substance we possess for promoting the growth ef vegetables? What are the principal ingredients in urine? Why should all farm stock be kept in stables during the winter? How, and for what purpose should cellars be constructed under the stables?

provided for that purpose, and from which it may be conveniently conducted to any part of the cellar.

3d. When winter approaches, and the time for stabling the stock comes, let the whole bottom and edges of the cellar be covered several inches deep with swamp muck, or chip manure, or clay, or even common earth, and then let all the solid excretions, litter, &c., from the stables or elsewhere, be thrown directly into the cellar, through convenient trap doors prepared for that purpose, instead of being thrown out of doors to be washed by rains and lost. At the same time, let the troughs which conduct the urine from the stables be so arranged as to pour that material directly upon the other matters thrown into the cellar. A little corn, or other grain, should be daily scattered over this, and the hogs allowed free access, for the purpose of inducing them to root over and thoroughly mix the whole.

4th. Let the farmer always keep on hand a few bushels of air-slacked lime, and a few wagon loads of muck, clay, or chip dung, and all the leached ash, dried and broken bones, refuse or spoiled fruits, or other gleanings of the farm; and every two or three days let a thin layer of these substances be spread over the products of the stable in the cellar, and perhaps once a week scatter over it half a bushel or more of the lime.

By this method an immense bed of the richest manure is accumulated every winter, ready for use in the spring, and of a quality amply sufficient to enrich every cultivated field on any farm of reasonable size. And every farmer who faithfully applies

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How should these cellars be prepared for the reception of manures? What materials should be permitted to go into the cellar? How should they be mixed? What should the farmer always keep on hand? What should he do with them? And how often? What is the result of such a course? Why will not the farmer who follows this method complain of "worn-out fields?"

the manure so formed, will never complain of "worn-out or barren fields."

The great advantages of this method are, 1st, It accumulates and saves everything capable of being converted into manure; 2d, The lime, muck, &c., distributed through it, absorb and retain all the gaseous substances formed; and, 3d, It is so sheltered above, and lined with muck or earth beneath, that all the liquid and soluble materials are retained. Hence one ton of such manure is more valuable for promoting the growth of any crop, than six, or even ten tons taken from the open barn-yard in the ordinary way; and also far better than the best compost prepared without the addition of urine.

Two objections would doubtless be urged by many agriculturists who have given but little attention to the subject. The first is, that the method would involve too much expense and labor in stabling the stock, preparing the cellars, &c.; and second, that such a bed of fermenting manure underneath the barn or stable, would be very offensive.

Concerning the first, we reply, that abundant experience has proved it both cheaper and easier to winter stock in the stable, than out of doors, exposed to all the storms and changes of our inclement seasons. Indeed, so true is this, and so much better is the condition of the stock in the spring, that most intelligent farmers of the present day stable all their cattle and horses, and provide good shelter for their sheep. The stables should always be kept well ventilated and cleanly.

What is the first great advantage of this method? What is the second? What the third? What is one ton of such manure equal to, for promoting the growth of farm crops? How does it compare with good compost? What objections would naturally be urged against this method? What has experience proved in regard to the first objection? How do the most intelligent farmers treat their stock during the winter? How should the stables be kept?

In regard to the expenditure for lime, and the labor in drawing muck, &c., we would ask which the farmer would prefer—to spend five or ten dollars per annum for lime and plaster, and four or five days' work with a team, to haul muck, clay, or earth, to prepare the cellar, and thereby obtain a bed of manure which will enable him to obtain, by the same labor in cultivation, 30 or 35 bushels of wheat from every acre which would produce but 15 before; 50 bushels of corn instead of 20 per acre; and 400 bushels of potatoes instead of 200: or to move on, wasting the most valuable part of his manure, starving his soil, permitting enough of his stock to die annually from exposure to the cold and storms of winter, to half pay for building a good stable to keep them in; forever grumbling about the hardness of his lot in getting but half a crop from his fields; and, finally, starving out himself, or emigrating to some far-off land of promise?

And in reference to the second objection, it is only necessary to add that the lime and earthy matter, from time to time scattered over the cellar, wholly prevents the disagreeable odor, by absorbing the gases on which it depends. Sometimes, when a farmer has a cold clay field to render fit for cultivation, it will be best to save a good supply of straw, undecayed, to plough into it, in connection with a coat or layer of sand and gravel from the nearest sand hill.

In the vicinity of large manufacturing establishments, much valuable additional manure may be

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How are the expenditures for cellars, lime, muck, &c., more than repaid? How much may the product per acre of wheat, corn, potatoes, &c., be increased by the judicious preparation and application of manure? How is the second objection answered? To what kind of soil may undecayed straw be applied with benefit? What valuable materials may be obtained from manufacturing establishments?

obtained, by gathering the refuse wool, hair, hoofs, &c., and adding them to the cellar or compost heap. And all that has been said concerning the value of animal excretions, will apply also to those of man; which may be found fully treated of in numerous agricultural papers and essays, under the head of *Night Soil*. The same principles will apply in the preparation and application of this, as in all other animal excretions.

Much more might be written on the subject of manuring, but it is the object of this work to present general principles, rather than minute detail. For if the farmer understands fully the object to be accomplished, he will seldom fail to find a way to accomplish that object, suited to his circumstances.

These objects, we repeat, are: 1st. To obtain as large a quantity of organic and inorganic manures as possible. Hence all the solid and liquid excretions of animals, or farm stock; all the straw, refuse hay, spoiled fruit, decayed chips, peat, muck, &c., must be saved for the first; and all the ash, leached and unleached; bones, dried and crushed, or pulverized; soot, lime, plaster, &c., for the last.

2d. It is the soluble part of all manures that is valuable for promoting vegetation; and as this is particularly liable to be washed away by rains, all manures should be protected by sheds, barn-cellars, or something equivalent.

3d. All vegetable and animal substances in a state of decay, like barn-yard manure, emit ammonia and other gaseous substances, which, if not absorbed, escape into the air and are lost. Hence this should

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What should always be the first object of the farmer in regard to manures? What then should he be careful to save? Why should all manures be protected by sheds, cellars, or something equivalent? What do all decaying vegetable and animal substances emit? How can the escape of these be prevented?

always be prevented by the addition of dried clay, air-slacked lime, plaster, powdered charcoal, leached ash, or even common soil.

CHAPTER VII.

The best Modes of analyzing Vegetable Substances and Soils, with Tables showing the composition of various Grains, Grasses, Soils, &c., according to the Analysis of the best chemists.

From what has been said in preceding chapters, every scholar will readily perceive that a knowledge of the composition and properties of soils and vegetables is as necessary for the farmer, as a knowledge of the composition of drugs is to the physician.

Not only is such knowledge indispensable to enable him to adapt the kind and quality of his manure to his soil, but it is equally important in enabling him to adopt a judicious plan of rotation or succession of crops; for the principle on which every system of rotation should be founded, is that of annually applying to the same field a crop which mainly depends for its support on different substances from the one that preceded it—thereby preventing the soil from becoming too rapidly exhausted of any one of its valuable ingredients.

There are several methods of analysis adopted by different chemists; but we shall present that method only which seems to combine the greatest simplicity, accuracy and ease in its performance.

What is as necessary for the farmer, as a knowledge of drugs is to the physician? What will such knowledge enable him to do? On what principle should every system of *rotation* or succession of crops be founded? Why? Is there more than one mode of analysis?

Sect. 1. *Analysis of Soils.*

The object of every analysis of soils should be, to ascertain, 1st, The quantity of water it is capable of absorbing; 2d, The quantity of soluble and insoluble vegetable matter, called humus or geine, and humic and crenic acids; 3d, The quantity of lime, potash, soda, magnesia and ammonia—these are generally found in combination with acids, and are, hence, called salts; 4th, The quantity of oxide of iron, alumina and silex.

The soil to be analyzed should be taken fresh from the field, sifted through a fine sieve, and 1000 grains of it accurately weighed. Take 100 grains of this, place it on letter paper, and expose it to as high a temperature as possible without scorching the paper, until it is thoroughly dried, and weigh it again. The loss will indicate the quantity of water which the soil contained. Then expose it to the open air thirty-six hours, and weigh the third time. The amount gained after drying, will show the absorbent power of the soil.

The second process consists in taking 100 grains of the soil previously well dried, and add to it 50 grains of carbonate of potash, dissolved in four ounces of water. Boil it half an hour, let it settle, and pour off the clear liquid, and wash the residue in four ounces more of boiling water. Throw the whole on a filter, which has also been carefully weighed, and continue to add water until it passes through the filter colorless and tasteless. Then dry the filter, with its contents, at a temperature equal to boiling water, until it is as dry as before the process was be-

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What are the several objects to be accomplished in every complete analysis of soils? In what state should the soil intended for analysis be taken? What are the two first steps to be taken? How do you find the quantity of water in the soil, and the quantity it is capable of absorbing?

gun. Weigh it carefully, and the loss sustained will indicate the quantity of soluble vegetable matter in the 100 grains of soil. The vegetable matter remains in the water, imparting to it a brownish color.

To ascertain the quantity of insoluble vegetable matter, place the contents of the filter just mentioned in a crucible, (it should be platina,) and heat it to full redness, when the vegetable matter will disappear. If any animal matter is present, it will emit a smell resembling burnt feathers. After the burning is completed, place the contents of the crucible back on the filter, and weigh as before. The loss sustained will show the quantity of insoluble vegetable and animal matter contained in the 100 grains of soil.

Fig. 2.

Crucible.

To accomplish the third object, take 100 grains more of the dried soil; expose it in a crucible to a full red heat, to destroy the vegetable and animal matter; then place it in a small glass flask, and pour on it two drachms of muriatic acid and six drachms of water. Note whether any effervescence ensues, which will indicate the presence of a carbonate, generally of lime or potash. Add two drachms more of acid, and boil half an hour over a spirit lamp. Throw the whole on a filter, previously weighed, and continue to wash it with water until it passes through the filter tasteless. Dry the filter

Fig. 3.

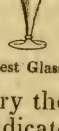
Flask.

How do you ascertain the quantity of soluble vegetable matter contained in 100 grains of soil? To how high a temperature must it be exposed in drying? What becomes of the soluble vegetable matter? How do you ascertain the quantity of insoluble vegetable matter? How do you know whether animal matter is present? How do you ascertain the quantity of soluble salts of lime, potash, soda, &c.? How can you know whether any of the salts were in combination with carbonic acid? How long must the boiling be continued in this process?

with its contents, as already directed, and weigh again. The loss sustained will indicate the quantity of soluble salts of lime, potash, &c., while the contents of the filter will be mostly silex or siliceous sand.

To ascertain the quantity of each salt, take the acid liquid obtained from the last filtering, and place it in a glass flask; add to it a few drops of nitric acid, to peroxidize whatever iron there may be present, and boil it. Then, while warm, add liquid ammonia as long as a precipitate continues to fall down. Filter the whole as directed in other cases, dry the contents of the filter, and their weight will indicate the quantity of oxide of iron and alumina in the 100 grains of soil.

Fig. 4.



Test Glass.

Then take the ammoniacal solution which passed through the filter, add to it a solution of oxalic acid or oxalate of ammonia, which will precipitate all the lime in the form of an oxalate. This must be separated by filtering, drying and weighing, as before; which will show the quantity of oxalate of lime, which is composed of oxalic acid and water 54 parts, and oxide of calcium or lime 28.5 parts.

To determine the quantity of magnesia, add to the liquid left, after separating the lime, a solution of phosphoric acid, which will precipitate the magnesia in combination with phosphoric acid and ammonia. This must also be separated by filtering, drying at a high heat to drive off the ammonia, and weighing; the result will give the weight of the

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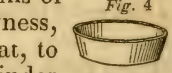
What remains on the filter after drying? How do you ascertain the quantity of each salt? What will precipitate the oxide of iron and alumina? How are they separated? What will precipitate the lime? What is the composition of oxalate of lime? What will separate the magnesia? How can the ammonia be separated from the precipitate?

phosphate of magnesia, which is composed of phosphoric acid 35.7, and magnesia 20.7 parts. Hence by deducting the proportion of acid, the quantity of magnesia in the 100 grains of soil will be shown.

There may be still left in the solution, potash, soda and manganese. If a stream of sulphuretted hydrogen gas is now passed into it, the manganese will be precipitated in the form of sulphuret, and may be separated by the filter. The contents of the filter should be heated to redness, and the manganese will be converted into a black oxide, when it may be weighed.

The remaining solution, containing whatever potash and soda there was in the 100 grains of soil, should now be evaporated to dryness, and the residue heated to a red heat, to drive off the ammonia. The remainder now consists of phosphate of potash and soda, with perhaps a trace of these alkalies combined with sulphuric acid.

Fig. 4



Evaporating Dish.

To determine the quantity of potash, re-dissolve the dry salts in pure water, and precipitate the potash by adding a few drops of chloride of platina; filter, dry, and weigh as usual. The dried precipitate will consist of a chloride of platina and potash, in the proportion of chlorine 72 parts, platina 98.6 parts, and potassa or potash 47.15 parts. By deducting the proportions of the two former, the quantity of the latter will be ascertained. The loss which now remains in the liquid, of the 100 grains of soil, may be considereed, in part at least, as some salt of soda.

Of what is the phosphate of magnesia composed? What may still be left in the solution after all these substances have been separated? How may the manganese be separated? How can the potash and soda be obtained? Why do you heat the residue to redness? With what acids may the potash and soda be combined? What substance will separate the potash after it has been re-dissolved?

For all practical purposes, it is unnecessary to separate the potash and soda; as the action of these alkalies on vegetation is in all respects very similar. The result of the analysis may then be stated in a tabular form, as follows, viz :—

1	Water of absorption, "	6	Salts of lime, "
2	Soluble vegetable matter, "	7	do. magnesia, "
3	Insoluble do. do. "	8	do. manganese, "
4	Silex & silicates insoluble, "	9	do. potassa, "
5	Oxide of iron and alumina, "	10	do. soda and loss, "

The question whether the earths and alkalies were principally carbonates or not, will be determined by the amount of effervescence when the muriatic acid is added in the first part of the analysis. The immediate fertility of any soil will depend principally on the quantity of soluble vegetable matter and salts of lime, potash, magnesia, &c., which it contains. Its capability of being *made* fertile by proper cultivation, will depend, also, on the quantity of insoluble vegetable matter and alumina.

An analysis sufficient for most practical purposes, would consist in taking 100 grains of soil, well dried, place it in a crucible and heat it to redness until all the vegetable and animal matters are burned off. Weigh it carefully, and the loss will indicate the quantity of organic matter. Put the burned earth into four drachms of diluted muriatic acid. Boil it half an hour, and throw the whole on a filter, and continue to add warm water until it comes through the filter colorless and tasteless. Then dry the contents of the filter and weigh again. The quantity

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Is it necessary for practical purposes to separate the potash and soda? Why? How may the result of the analysis be stated? How can you tell whether the earths and alkalies were principally carbonates? Upon what will the immediate fertility of any soil depend? Upon what its capability of being made fertile? How may an analysis sufficient for most practical purposes be made?

will show the amount of silex and insoluble silicates, or, as Dr. Dana calls it, granitic sand; and the loss will indicate the quantity of soluble salts, capable of being acted on by living vegetables.

The following tables exhibit two conditions of the same soil. The one marked A, is in its natural state, and capable of producing but ten bushels of corn per acre, and less of other grain. The second, marked B, is in a high state of cultivation, and produces sixty bushels of corn, or two tons of hay per acre. They were analyzed by Dr. C. T. Jackson.

	A.	B.
Water of absorption,	1.80	1.55
Soluble vegetable matter,	2.50	4.60
Insoluble do. do.	2.00	1.50
Peroxide of iron,	2.10	2.07
Alumina,	2.10	1.39
Magnesia	1.00	00
Phosphate and crenate of lime,	00	a trace.
Silex and insoluble silicates,	88.20	89.10
	99.70	100.21

Here almost the only difference between the soil, in its native state, and when brought to a very high degree of fertility, consists in almost doubling the quantity of *soluble vegetable matter*.

The following exhibits the composition of two soils, one (A) from Lasalle county, Illinois, and never cultivated; and the other (B) from the Sciota valley, Ohio, cultivated fourteen years without manure. Both belong to the best quality of soils, and were analyzed by Prof. Hitchcock.

What do the two following tables exhibit? In what state is the soil in the table marked A? How much corn is it capable of producing to the acre? In what state is that in the table marked B? How much is it capable of producing? What constitutes the difference between the two? What do the two following tables represent? How long has the soil B been cultivated without manure? By whom were they analyzed?

	A.	B.
Soluble vegetable matter,	7.6	4.5
Insoluble do. do.	13.8	6.7
Sulphate of lime,	18.4	2.1
Phosphate of lime,	0.4	0.9
Carbonate of lime,	3.3	2.8
Silicates, (of potash and alumina,)	73.5	83.0
Water of absorption,	9.5	5.3
	126.5	105.3

These tables are not only sufficient as examples of the composition of soils, but they illustrate one of the most important facts in practical agriculture, viz :— 1st, That the fertility of the soil depends, in a *very great* measure, on the quantity of soluble vegetable matter and soluble salts which it contains; and 2d, That both are constantly *abstracted* by cultivation, thereby reducing the soil ultimately to entire barrenness, unless renewed by judicious *manuring*.

Thus, in the two last specimens given, the soil from the Sciota valley, originally as rich in these substances as any in the world, after a cultivation of fourteen years without manure, gives but half of the vegetable matter, and less than half of the salts, which are found in the new soil from Laselle county, Illinois. What a lesson this to those farmers who waste all their manure, or, at least, all the soluble parts of it, and then complain of "poor crops" and "worn-out fields!"

To give an idea of the absolute amount of materials in an acre of soil, of six inches depth, we add the following analysis and estimate of a soil from the farm of J. P. Cushing, Esq., of Watertown,

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What has been the effect on its composition as compared with the soil A? What do these examples illustrate? On what then does the fertility of the soil mostly depend? What effect is produced on these ingredients by cultivation? What is the only remedy for this? What does the next table exhibit?

Mass., made by Dr. C. T. Jackson. The soil originated principally from granite rocks, and has been kept in a good state of cultivation.

Insoluble silicates,	664.045	tons per acre.
Alumina,	35.219	do. do.
Peroxide of iron and manganese,	34.494	do. do.
Phosphate and crenate of lime,	4.311	do. do.
Soluble vegetable matter,	26.733	do. do.
Insoluble do. do.	54.329	do. do.
Water,	39.678	do. do.
Specific gravity of the soil,	1.277	do. water being 1.

1 cubic foot weighed 79.181 pounds.

The potash in the above is included in the insoluble silicates and alumina.

Sect. 2. *Analysis of Vegetables.*

It has already been stated, that all vegetable substances are composed of oxygen, hydrogen, carbon and nitrogen, with small quantities of silica, alumina, oxide of iron, magnesia, manganese, lime, soda, potash, sulphur, phosphorus and ammonia.

The first three of these substances form the principal part of the bulk of all plants. Nitrogen is also found in all, or in some parts of all, but in much less quantity than either of the other three. These four constituents, combined in various proportions, form all the proximate elements—such as vegetable acids, alkalies, gum, starch, gluten, &c. But as the supply of these constituents from the atmosphere and water is inexhaustible, a knowledge of the precise

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By whom was the table made? From what did the soil originate, and what is its present condition? Of what are all vegetable substances composed? Which of these form the principal bulk of plants? Is nitrogen found in all? What do these four constituents form? Why is not a precise knowledge of the proportions in which these substances exist in different plants practically important?

proportions in which they exist in different plants is of very little practical importance.

The same may be said of the silica and alumina; but not so with the remaining inorganic ingredients which we have named. It will be seen by our analysis of soils, that they exist in comparatively small quantities, even in the most fertile specimens, and hence they soon become exhausted by frequent cropping. They do not all, however, enter equally into the composition of each species of plant, and therefore it becomes important to the agriculturist to know the usual composition of each species, that he may adopt a judicious succession or rotation of crops. By this means, he may prevent the soil from being exhausted of the same ingredients every year, without allowing time for their renewal from the coarser gravel, stones, &c., by the ordinary disintegrating agents.

MODE OF ANALYSIS.

The vegetable substance to be analyzed should first be thoroughly dried, at a temperature just below that necessary to scorch white paper. It should then be weighed and placed in a crucible heated sufficiently to *burn it completely to ash;* or, in other words, to expel all the organic constituents. Weigh the ash, and the loss by burning will show the quantity of oxygen, hydrogen, carbon and nitrogen which the specimen contained; and the ash will contain

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Why is the proportion of mineral ingredients much more important? Do all the inorganic or mineral ingredients enter equally into the composition of all plants? What is the first step in the analysis of vegetable substances? How do you expel the organic ingredients of the substance to be analyzed? How do you ascertain the quantity of all these? Of what is the ash composed?

the inorganic ingredients in the form of salts: i. e., combined with some acid.

One hundred grains of this should be taken, and boiled in two ounces of distilled water. The whole should then be thrown on a filter, and washed with distilled water until it passes through clear and tasteless. The contents of the filter must be thoroughly dried and weighed again. The loss will indicate the quantity of soluble salts of potash and soda in the 100 grains of ash. The contents of the filter may now be placed in a glass flask, and boiled in two drachms of muriatic acid, diluted with two ounces of distilled water. Then treat it in all respects as we have detailed in the process for analyzing soils; beginning with the addition of muriatic acid in that process. The presence of carbonic acid will be shown by the effervescence which follows the addition of the muriatic acid. But the precise quantity of this, or of the sulphuric or phosphoric acids, it is not material for the practical agriculturist to determine.

The summing up of an analysis of vegetable substances may be stated as follows :—

1	Organic matter, (oxygen, hydrogen, carbon and nitrogen,)	" per cent.
2	Inorganic matter (ash,)	" "

One hundred parts of the ash contain—

1	Soluble salts of potash and soda,	" per cent.
2	Oxide of iron and alumina,	" "
3	Salts of lime,	" "
4	Salts of magnesia,	" "
5	Oxide of manganese,	" "
6	Silex and silicates,	" "

How can you determine the quantity of soluble salts contained in the ash? How may the remainder of the process be conducted? How will you know whether carbonic acid is present?

The following tables have been collected with much care, and show the composition of the various grains, grasses, roots, &c., of the farm :—

1.—ANALYSIS OF WHEAT.

Thus 100 lbs. of	wheat,	of wheat straw,
yield of organic elements,	98.82 lbs.	96.49 lbs.
" ash,	1.18 "	3.51 "
100 grs. of the ash of	wheat,	of wheat straw,
contain of potash and soda,	37.72 grs.	1.42 grs.
" lime,	1.93 "	7.12 "
" magnesia,	9.60 "	0.91 "
" oxide of iron,	1.36 "	—— "
" sulphuric acid,	0.17 "	1.05 "
" phosphoric acid,	49.32 "	4.84 "
" silica,	——	81.77 "

2.—ANALYSIS OF INDIAN CORN.

100 lbs. of	Indian corn,	corn stalks,
contain organic ingredients,	99.05 lbs.	97.44 lbs.
" ash,	0.95 "	2.56 "
100 grs. of the ash contain in the	corn,	corn stalks,
potash,	20.87 grs.	24.00 grs.
lime,	9.72 "	5.02 "
magnesia,	5.76 "	0.08 "
phosphoric acid,	18.80 "	2.00 "
sulphuric acid,	trace.	1.05 "
silica,	39.00 grs.	50.01 "
alumina,	trace.	16.04 "

3.—ANALYSIS OF THE OAT.

100 lbs. of	oats,	oat straw,
contain of organic elements,	97.42 lbs.	94.26 lbs.
" ash,	2,58 "	5.74 "

What do the following tables show ? Which yields the greatest proportion of ash, wheat or wheat straw ? Of what is the ash of wheat principally composed ? What is the most prominent ingredient in the ash of wheat straw ? How much ash will 100 lbs. of Indian corn yield ? How much will 100 lbs. of corn stalks ? What are the three most important ingredients in the ash of corn ? What marked difference is there in the composition of the ash of wheat, and that of corn ? How much ash will 100 lbs. of oats yield ? How much 100 lbs. of oat straw ?

100 grs. of the ash contain, of			
potash and soda,	19.12 grs.	15.18	grs.
lime,	10.41 "	2.63	"
magnesia,	9.98 "	0.40	"
oxide of iron,	5.08 "	——	"
oxide of manganese,	1.25 "	——	"
phosphoric acid,	46.26 "	0.17	"
sulphuric acid,	—— "	1.37	"
silica,	3.07 "	79.93	"

4.—ANALYSIS OF BEANS.

100 lbs. of	beans,	bean straw,
contain of organic elements	97.86 lbs.	96.88 lbs.
" ash,	2.14 "	3.12 "
100 grains of the ash contain,		
potash and soda,	39.42 grs.	54.50 grs.
lime,	4.10 "	19.87 "
magnesia,	7.04 "	6.69 "
sulphuric acid,	trace.	1.09 "
phosphoric acid,	46.75 "	7.27 "
silica,	1.00 "	7.05 "

5.—ANALYSIS OF RYE.

100 lbs. of	rye,	of rye straw,
contain of organic elements	97.70 lbs.	96.40 lbs.
" ash,	2.30 "	3.60 "
100 grs. of the ash contain of		
potash,	32.76 grs.	17.19 grs.
soda,	4.45 "	—— "
lime,	2.92 "	9.06 "
magnesia,	10.13 "	2.41 "
oxide of iron,	0.82 "	1.36 "
phosphoric acid,	47.29 "	3.82 "
sulphuric acid,	1.46 "	0.83 "
silica,	0.17 "	64.50 "

What are the three most prominent ingredients in the ash of oats? How do they compare in quantity with the same ingredients in the ash of wheat? Which yields the greatest proportion of ash, beans or bean straw? What marked difference is there in the composition of bean straw and oat straw? Which yields the largest proportion of ash, wheat or rye? What are the three principal ingredients in the ash of rye?

6.—ANALYSIS OF POTATOES.

100 lbs. of	potatoes,	of potato vines.
contain of organic elements	97.40 lbs.	95.21 lbs.
" ash,	2.60 "	4.79 "
100 grs. of the ash contain,		
of potash and soda,	48.50 grs.	2.80 grs.
lime and magnesia,	14.19 "	20.30 "
phosphoric acid,	36.31 "	10.10 "
sulphuric acid,	0.50 "	2.00 "
silica,	—— "	63.40 "

7.—ANALYSIS OF TURNIPS.

100 lbs. of	turnips,	of turnip-tops,
contain of organic elements	92.40 lbs.	97.04 lbs.
" ash,	7.60 "	2.96 "
100 grs. of the ash contain, of		
potash and soda,	44.60 grs.	
lime and magnesia,	11.30 "	
phosphoric acid,	37.00 "	
sulphuric acid,	1.70 "	
silica,	—— "	

8.—ANALYSIS OF GRASSES.

The following table will show the composition and quantity of ingredients in 1000 pounds of hay from

	Rye Grass.	Red Clover.	White Clover.	Lucerne.
Potash,	9 lbs.	20 lbs.	31 lbs.	$13\frac{1}{2}$ lbs.
Soda,	4 "	$5\frac{1}{4}$ "	6 "	6 "
Lime,	7 "	28 "	$23\frac{1}{2}$ "	48 "
Magnesia,	1 "	3 "	3 "	$3\frac{1}{2}$ "
Oxide of iron,	trace.	trace.	$\frac{1}{2}$ "	$\frac{1}{3}$ "
Silica,	28 "	4 "	15 "	$3\frac{1}{3}$ "
Sulphuric acid,	$3\frac{2}{3}$ "	$4\frac{1}{2}$ "	$3\frac{1}{2}$ "	4 "
Phosphoric acid,	$\frac{1}{4}$ "	$6\frac{1}{2}$ "	5 "	13 "
Chlorine,	trace.	$3\frac{1}{2}$ "	2 "	3 "

How large a proportion of potash and soda is there in the ash of potatoes? How much in the ash of potato vines? What does the ash of turnips closely resemble in its composition? Which yields the largest proportion of ash, turnips or potatoes? How much potash is there in 1000 pounds of rye grass? How much in the same quantity of red clover? How much in white clover? Which of the grasses contain the largest proportion of lime? Which the largest proportion of silica?

9.—ANALYSIS OF RICE.

Clean commercial rice gave by burning, of

organic ingredients,	99.51 per cent.
ash,	49 "

100 grains of this ash gave, of

phosphate of lime,	76.20 grs.
phosphate of potash,	5.00 "
silica,	20.00 "
sulphate of potash,	trace.
chloride of potassium,	trace.
carbonate of lime,	trace.
carbonate of magnesia,	trace.

Rice	chaff,	straw,
contain of organic ingredients	86.33 per cent.	87.58 per cent.
ash,	13.67 "	12.42 "

100 grs. of ash contain, of

phosphate of lime,	1.00 grs.	1.90 grs
carbonate of lime,	22 "	2.00 "
phosphate, sulphate, chloride, carbonate, of potash,	1.13 "	2.56 "
oxide of iron and manganese,	02 "	10 "
silica,	97.55 "	84.75 "
potash combined with silica,	—— "	8.69 "

10.—ANALYSIS OF COTTON.

The following table shows the composition of cotton wool and cotton seeds from Santee :—

	cotton wool,	cotton seeds,
organic ingredients,	99.08 per cent.	96.15 per cent.
ash,	0.92 "	3.85 "
100 grs. of ash contain, of		
potash,	31.09 grs.	19.40 grs.
lime,	17.05 "	29.79 "
magnesia,	3.26 "	trace.
phosphoric acid,	12.30 "	45.35 "
sulphuric acid,	1.12 "	1.16 "
chlorine.	trace.	trace.

How much ash will 100 lbs. of clean commercial rice yield? What are the three principal ingredients in this ash? How large a proportion of ash can be obtained from rice chaff or straw? How large a proportion of silica is contained in the ash of rice straw? What are the three principal ingredients in the ash of the cotton plant?

11.—ANALYSIS OF THE YAM.

The yam or sweet potato contains, of	
organic ingredients,	98.91 per cent.
ash,	1.09 "
100 grs. of ash contain, of	
potash,	43.59 grs.
lime,	10.12 "
magnesia,	3.80 "
phosphoric acid,	11.08 "
sulphuric acid,	31.90 "
chlorine,	2.18 "
potassium,	2.42 "

The above tables Nos. 9, 10, 11 and 12, showing the composition of rice, cotton, and the yam or sweet potato, are derived from an analysis made by Chas. U. Shepard, M. D., Professor in the Medical College of South Carolina. The remaining ones have been gathered from the agricultural writings of Prof. J. F. W. Johnson, and from the American Quarterly Journal of Agriculture—except Nos. 5, 6 and 7, and the corn-stalks in No. 2, which were furnished from the laboratory of the author.

It will be seen that nearly the same ingredients enter into the composition of all the vegetables, but in very variable proportions. Thus, while wheat contains 1.18 pounds of mineral ingredients in every 100 pounds of the grain, of which 37 per cent. is potash and 49 per cent. phosphoric acid, the same quantity of corn contains only 0.95 of a pound of mineral ingredients, of which only 20 per cent. is potash, and 18 or 19 per cent. phosphoric acid. Hence 100 pounds of wheat robs the soil of nearly

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What is the principal difference between the composition of the *yam* or sweet potato and the common Irish potato? To whom are we indebted for tables number 9, 10, 11, and 12? From what sources have the remaining tables been obtained? In what respect do the ingredients of vegetable substances vary? How much more phosphoric acid and potash is there in 100 lbs. of wheat than in 100 lbs. of corn?

as much potash, and more phosphoric acid than 200 pounds of corn.

Again, in the grasses, we find in every 1000 lbs. of rye grass, 53 pounds of mineral ingredients, of which 9 pounds are potash, and only 1-4 pound of phosphoric acid ; while in the same quantity of white clover we have 89 1-2 pounds of mineral ingredients, of which 31 pounds are potash and 5 pounds phosphoric acid. Hence one ton of white clover would take from the soil more than three times as much potash, and twenty times as much phosphoric acid, as one ton of rye grass.

These facts explain why two or three crops of one kind may be taken from the same soil, with less apparent effect than one crop of another kind. To this, however, we shall recur again, when speaking of the rotation of crops.

The reader will doubtless find many discrepancies between the analyses, as given in the several tables, and others made and published by other chemists. This difference, however, is not owing to errors in the analyses, but to the fact, now abundantly proved, that the specimens analyzed grew on different soils. For instance, Prof. Norton, in a late number of the Amer. Jour. of Science and Arts, gives the amount of ash contained in two specimens of oat chaff. The first, which was grown on a " poor mossy soil," gave only 7.23 per cent. of ash ; while another, of the same variety of oats, grown on a different soil, gave 16.53 per cent.

But this does not invalidate the truth, or diminish the importance, of the conclusions drawn from comparing the composition of different species of grain. It only renders it necessary that, in making such

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How do you explain why two or three crops of one kind of grain may be taken from the soil with less apparent injury than one of another kind ? Does the composition of plants vary with the soil on which they grow ?

comparisons, we take care that the several species analyzed are taken from the same soil. Otherwise the comparison would not be a fair one.

CHAPTER VIII.

Practical Agriculture and Horticulture.

A perusal of the foregoing pages will lead to the following general conclusions, viz:

A. That the only means of acquiring an exact knowledge of the composition of both soils and vegetables, consists in chemical analysis. And whenever any soil proves unproductive, an analysis will show the cause, and of course the proper remedy.

B. Five substances are necessary in every cultivatable soil, viz: silica, alumina, lime, potash, and humus or vegetable matter. And it is made much better by the addition of a small quantity of magnesia, oxides of iron and manganese, sulphur and phosphorus. Perhaps the best proportions in which these substances can be combined for all purposes are as follows:—Silica 70 parts, alumina 10, lime 3, oxide of iron and manganese 4, vegetable matter 8, phosphoric acid 2, potash 2, magnesia 0.5, and soda 0.5.

C. The fertility of every soil depends on the *state* of its ingredients, as well as their quantity and proportion. Thus the *finer* the mineral ingredients are reduced and the more *soluble* the vegetable, the more productive will be the soil.

What does this render necessary in making comparisons? Of what does chapter 8th treat? What is the only means of acquiring an exact knowledge of the composition of soils and vegetables? How many substances are necessary in every cultivatable soil? Can you name them? The addition of what substances will make it still better? On what does the fertility of every soil depend? In what ratio will the soil be productive?

D. All those substances which our soils require to insure a high degree of fertility, are within the reach of every farmer. And hence no excuse can be rendered for barren fields or unproductive farms.

The object of the present chapter will be to give a brief account of the germination of seeds; assimilation or nourishment of plants, with the influence of heat, light and electricity; a particular description of the various grains and grasses, with their mode of culture; rotation of crops; connection of farm stock with vegetation; and the propagation of plants, fruit trees, &c., by seeds, eyes, cuttings, graftings, and budding.

Sect. 1. *Germination of Seeds.*

All seeds contain a principle of life or vitality. And though that principle may remain dormant a long time when the seeds are fully ripe and kept dry, yet whenever they are exposed to a certain degree of heat and moisture, with access of air, that life is stimulated into activity, and the seed is said to sprout or germinate.

Every seed is made up of a radicle, which strikes downward to form the root; a plumula, which shoots upward to form the stem; and, with few exceptions, a cotyledon or cotyledons, which form the first leaf or leaves of the growing plant.

Three conditions are necessary for the germination of seeds, viz: a temperature of 60° Fahrenheit or

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What is within the reach of every farmer? What do all seeds contain? Under what circumstances does the principle of life remain dormant or inactive? When does it become active? What is this activity or sprouting called? Of how many parts are seeds composed, and what are they called? Do all seeds possess cotyledons? From what part of the seed is the root derived? How many conditions are necessary for the germination of seeds, and what are they?

over; a certain degree of moisture, or, in other words, the presence of water; and the free access of atmospheric air. Hence all soils designed for the reception of seeds should be fine, light and porous, so as to admit the requisite quantity of air and moisture; and the temperature should be at least 60°. If the soil is too dry, the vitality of the seed will remain dormant; or if moisture is present, and the air is excluded, or the temperature is too low, it will decay and be lost.

But when all these conditions are fulfilled, the seed first absorbs water and swells or increases in bulk; oxygen is absorbed from the air or decomposed water; this unites with the carbon in the seed, and forms carbonic acid. The starch in the seed is converted into sugar, and the gluten or principles of the seed which contain nitrogen, is converted into a substance peculiar to germinating seeds or young shoots, called diastase. While these changes are going on, the swelling of the seed bursts its outward covering; the radicle extends itself downward into the soil, while the plumula rises upward, and sooner or later appears above the surface.

Thus far the germ is supported solely by the nutritious matter contained in the seed itself, with the addition, perhaps, of oxygen from the air or water. But as soon as the tender radicle or root has struck into the soil, it begins to absorb the soluble vegetable products and salts which are there contained;

In what condition then should the soil be when fitted for the reception of seed? If the soil be too dry, what will be the effect? What if the air be excluded or the temperature too low? What is the first change that takes place in the germination of seeds? What simple substance is absorbed? What becomes of the starch in the seed? What becomes of the gluten, or parts containing nitrogen? While all these changes are going on, what else takes place? How has the germ been thus far supported? What takes place after the radicle or root has extended itself into the soil, and the leaf or leaves opened into the air?

and the first leaf or leaves that expand commence the work of absorbing carbonic acid from the air, and assimilating its carbon, while the oxygen is emitted again free. In this way the plant continues to be nourished until it attains its full growth and perfection, receiving most of its carbon and nitrogen from the carbonic acid and ammonia of the atmosphere; and its water, with salts and inorganic substances, from the soil.*

If it is asked by what agency these substances are absorbed by the roots and leaves? we answer, first, by the laws of *imbibition*, aided doubtless by the electric currents which are established by the roots and the different ingredients of the soil. The leaves and roots, as well as the stems of all plants, are porous. And it is a well-known law, that all porous or spongy bodies readily absorb or imbibe liquids; and that such absorption is greatly facilitated by the development of electric currents in the absorbing substance. The process has been called *Endosmose*, by the French chemists.

The silex of the soil is a negative electric when compared with alumina, lime, magnesia, &c., which

* The much disputed question, whether the carbonic acid and ammonia is absorbed directly by the leaves, or is carried by rains, &c., down into the soil, and there absorbed by the roots, and from thence transferred through the plant to the leaves, to be decomposed and appropriated for nourishment, we shall not attempt to settle at present, it being of very little practical importance.

Is the question whether plants absorb the carbonic acid and ammonia directly from the air through their leaves, or only from the soil through their roots, well settled? Is it a matter of much practical importance? By what agency does absorption take place in the roots and leaves of plants? What parts of plants are porous? What is a well-known law of porous bodies when in contact with liquids? What effect has electricity on absorption? What is the process of absorption or imbibition called by the French? In what electrical state is silex when compared with alumina and other mineral ingredients of the soil?

are positive. Hence the presence of roots and other vegetable matter generating acids, would be continually developing electricity in the soil, and thereby powerfully aiding the absorption and circulation of fluids in plants. Indeed, some have attempted to explain all the phenomena of vegetation, through the agency of this subtle fluid. But when we remember that all the experiments hitherto performed have not even formed one of the proximate elements of plants, and much less a single living vegetable, without a seed or scion to grow it from, we shall be compelled to call in the aid of the principle of life or vitality as a power superior to the ordinary chemical forces.

It is by this principle, and this alone, that we can explain how the seed which may have lain dormant for months or years, starts forth into active life on exposure to a certain degree of heat and moisture; and still more, how this life is maintained, with an annual increase of the size and height of the plant, for half a century or more, in despite of all the powers of gravitation, heat, cold, winds, rain, &c. It is by means of this vital power, aided by the influence of electricity, heat and light, that the plant is enabled to select from the heterogeneous or mixed ingredients of the earth and atmosphere, and assimilate or appropriate to itself only those materials proper for its nourishment, while all others are rejected. The fact that such *selection* takes place, is itself proof of the existence and controlling power of such a principle.

How have some attempted to explain all the phenomena of vegetation? What agency must we admit in the process, superior to the ordinary chemical forces? What enables the plant to select only those ingredients fitted for its own nourishment? What does the fact that such *selection* takes place, prove?

Plants, like animals, not only select and absorb through their roots and leaves the substances needed for their growth, but they at the same time cast off through the same organs whatever matters may have become useless or hurtful in them. Hence the roots of all plants are found to reject a considerable quantity of carbonaceous matter, while the leaves emit still larger quantities of oxygen and watery vapor. But as with animals, so with plants; the same substances which have been thrown out and rejected by the roots of one species, are taken up and appropriated by those of another. Hence, in part, the great utility of rotation or frequent change of crops on the same soil.

We might here enter upon a minute description of the spongelets, cells and internal structure of plants, called vegetable anatomy and physiology or biology; but it would serve to perplex the mind of the scholar rather than advance him in practical knowledge. This interesting branch of the study is more appropriate for the mind already matured and trained to close and patient thought.

We may state, however, that every vegetable, plant, shrub or tree, is made up of the bark or outer covering of the stem; the cuticle or covering of the soft parts, as the leaves, blossoms, &c.; the liber or inner bark, a substance intermediate between the bark and woody fibre; the woody fibre or solid part; and the pith or medullary matter. All these parts are made up of cells, or vesicles, or spongelets of various forms and sizes, so arranged as to leave

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What substances are emitted or thrown off by the leaves and roots of plants? Do the roots of all species of plants absorb and reject the same substances? What does this show in regard to the propriety of a change or rotation of crops? What are the several parts that make up the whole of a living plant or tree? What are all these parts made up of? How are the cells or spongelets arranged?

small spaces between them, through which the fluid substances taken up by the roots pass up to the branches and leaves, and which are called canals, tubes or vessels. There are also canals or vessels extending horizontally from the liber or inner bark to the pith. These are called medullary vessels or tubes.

The bark and cuticle are filled with pores, especially the latter, where it covers the under surface of the leaves. So numerous are these pores or openings in some places on the cuticle of plants, that they exist to the extent of more than 100,000 on one square inch of surface. It is chiefly through these that the transpiration of watery vapor takes place.

The growth of plants takes place by the addition of layers between the liber and the wood, called in its forming state *alburnum*. Hence, whenever wood is cut across horizontally, it presents the appearance of concentric layers.

Sect. 2. *Influence of Caloric, Light and Electricity.*

CALORIC.

It will be remembered that one of the properties of caloric is to expand all bodies within its influence; and hence its tendency is to expand the cells, tubes and pores of plants, and thereby facilitate their absorption, circulation and transpiration. It

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What are those spaces through which the fluids pass, called? In what other directions are canals or vessels found? What are they called? What parts do we find filled with pores? How numerous are these pores on some parts of the cuticle? What passes through these pores? How do plants grow? Why does wood present the appearance of concentric layers when cut across horizontally? What effect does caloric have on the pores, cells, &c., of plants? What effect does this have on their absorption and circulation?

will also be remembered, that latent caloric exists in all bodies, which is rendered free by every increase in their density. Hence, when gases and liquids are absorbed and converted into solid substances, large quantities of latent heat are set free; which is counteracted by the transpiration of gases and watery vapor.

Again, the kind of vegetables natural or peculiar to any region, seems to be regulated mainly by the temperature of such region. Thus, we never find barley or potatoes more than 80° north from the equator, and wheat not more than 64°; while, on the other hand, these same grains will not grow where the climate is too warm. The southern limit for the kinds of grain mentioned, is about 20° north of the equator.

The same variations of temperature limit the cultivation of grain and other vegetables on mountains. Thus, in the latitude of the Alps, wheat ceases to grow at the height of 3,400 feet; oats at 3,500feet; rye at 4,600; barley at 4,800. These lines of temperature do not follow the parallels of latitude on the earth's surface, but they vary with the varying geographical aspect of the country. Hence the same temperature, and consequently the same vegetation, is found several degrees farther north in some countries than in others. This is well illustrated by comparing the climate and vegetation of France with those of New-York and Pennsylvania.

What takes place when gases and liquids are converted into solid substances? How is the accumulation of caloric from this cause counteracted? What seems to regulate the kind of vegetables natural to any given region of the earth? Within what degrees or parallels of latitude will wheat grow? At what height does wheat cease to grow on mountains? Do the lines of temperature follow the parallels of latitude? What effect does this have on the vegetation of different countries in the same latitude?

LIGHT.

This agent, also, exerts a strong influence on vegetation, as is proved by daily observation. Those vegetables which grow in the shade are always pale and feeble when compared with those that receive the direct rays of the sun. Not only is the plant changed in color by the light, but also in taste and all other sensible qualities. And so strong is their affinity for light, that the leaves of some plants seem to follow the sun in its daily course.

The most important influence of light on vegetation, is its agency in enabling the leaves to decompose the carbonic acid of the atmosphere, and assimilate its carbon, while its oxygen is set free. Hence it exerts a direct and controlling influence over the process of nutrition. This is well illustrated by the appearance of vegetables grown in dark cellars. These facts should warn the agriculturist not to sow or plant his crops too thick or near together; as in all such cases the shaded state of the lower leaves prevents the full effect of the sun's rays on them, and consequently interferes with their nutrition and growth.

Whether the influence of light on vegetation is owing to the heating, or coloring, or chemical rays, or all combined, is still a matter of uncertainty. According to the observations of Prof. Draper, of New-York, the greatest influence is exerted by the yellow part of the colored ray.

Does light have any influence on vegetation? What is the difference between plants grown in the dark, and those fully exposed to the sun? What is the most important influence of light on vegetation? How is the effect of light on the nutrition of vegetables familiarly illustrated? What is the effect of allowing crops to stand too thick on the ground? Is it positively known whether the effect of light on vegetation is owing to one only, or all parts of the ray? What was the result of Prof. Draper's observations?

ELECTRICITY.

The influence which electricity exerts over the absorption and circulation of fluids or sap, in vegetables, we have already alluded to. It has long been known that the passage of electric or galvanic currents through the soil containing the roots of plants, would make them grow very rapidly; but, until recently, no means have been devised for rendering this knowledge available to the farmer.

The first attempts to apply it on a large scale were made in our country in 1843–4, by William Ross, who planted potatoes on the 6th day of May, 1843, and by the aid of electricity exhibited new potatoes at the meeting of the New-York Farmers' Club on the 2d of July following, two and a half inches in diameter; while others planted at the same time, and in the same field, were not larger than peas.

His mode of applying this agent, was to place at one end of his rows of potatoes a plate of zinc, and at the other a plate of copper, both being buried two inches below the surface of the soil, and connected together by a wire passing through the atmosphere. By this means a current of electricity was made to pass through the soil and roots of plants from one plate to another. More recently, many experiments have been performed, and not a few startling reports circulated through the agricultural papers concerning the application of atmospheric electricity on a large scale to agricultural purposes. But we believe a large majority of these experiments have been total failures.

What influence do electric or galvanic currents exert on the growth of vegetables? Who first attempted to apply electric currents directly to field crops, and when? What was his mode of applying this agent? Can we place much reliance on the reports recently made, through the papers, on this subject?

Indeed, knowing the conducting power of moist earth, and the tendency of electricity to diffuse itself, we do not perceive how any of the plans yet proposed can be rendered effectual to any considerable extent. The method adopted by Ross is undoubtedly the best; but the plates must be of considerable size, and the rows not too long. The mode in which electricity influences vegetation is, doubtless, by simply increasing the rapidity of the absorption and circulation of the sap, and consequently of the nutrition, in the same manner that electric currents facilitate capillary attraction in simple porous bodies.

Sect. 3. *Description of particular Grains, Grasses, &c., with their Mode of Culture.*

The cultivation of the various grains and grasses constitutes the chief business of the agriculturist. Of these, wheat, rye, oats, Indian corn or maize, barley, buckwheat, potatoes, turnips, beets, peas and beans, together with timothy grass and clover, are the most important in all the Middle, Western, Northern and Eastern States; while in the Southern and South-western part of the Union the culture of cotton, tobacco, and the sugar cane, is of prime importance. Hence we shall give a short account of each, in the order in which they are named.

WHEAT.

Two species of wheat are cultivated in this country, the Triticum Hybernum or winter wheat, and

Why cannot electricity or galvanism be made practically useful to the farmer by direct application to his crops? In what mode does electricity probably influence vegetation? What constitutes the chief business of the agriculturist? Which are the most important of these? What is of the most importance in the Southern and South-western States? How many species of wheat are cultivated in this country?

the Triticum Æstivum or summer wheat. The first, or winter wheat, requires to be sown in the autumn, and is not ready for harvest until the following July or August; while the summer wheat is sown early in the spring and harvested in August following. The winter wheat, which is the species chiefly cultivated, contains many varieties; but they may all be reduced to two classes, the dark colored or flint wheat, and the white or thin skinned. The latter flourishes best in warm, dry soils, and warm climates; while the former is best adapted to colder climates, and will endure a moist and heavy soil.

This kind of grain requires for its full perfection a large proportion of nitrogen, phosphates, and salts of potash. Hence the soil designed for its cultivation should be well drained, and thoroughly, deeply, and finely ploughed, to render it light and porous, that it may readily absorb moisture and gases from the air. It should also contain a large proportion of clay and lime; otherwise free and frequent manuring with marl, lime and ash, mixed with muck or stable manure, will be necessary; or, what is much better, fine compost or barn-cellar manure, fully impregnated with urine.

The addition of muck or ordinary barn-yard manure, without the aid of ammonia, lime, ash,

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What are they called? At what seasons of the year must they be sown? Which species is principally cultivated? What are the two principal varieties of this species? Which variety flourishes best in cold climates? Which on moist and heavy soils? What ingredients does wheat require in abundance for its full perfection? Why should the soil designed for the cultivation of wheat be drained, and deeply and finely ploughed? If it does not contain a large proportion of clay and lime, what substances should be frequently added as manure? Or what would be better than these? What effect would the addition of muck or ordinary barn-yard manure, without the ammonia, lime, urine, &c., have on the crop?

&c., or these same substances dissolved in water in the form of urine, will do little else than furnish carbon for an abundant growth of straw; but it will lack the requisite strength and firmness, be more liable to rust, and the heads will not be more than half filled, and the berry small.

The best wheat lands are those originally derived from argillacious slate or shale, mixed with more or less limestone, and well supplied with decaying vegetable matter; the whole being converted by cultivation into a deep, rich and porous loam. But no soil, however fertile in its natural composition, will bear long continued cultivation for the same crop, without becoming exhausted of some of its essential ingredients.

If we turn to the composition of wheat and wheat straw, we shall see that nitrogen, phosphoric acid, potash, lime and magnesia, enter largely into their composition, and hence these first become exhausted from the soil. Indeed, every ton of wheat removes from the soil at least twenty pounds of these substances, independent of the nitrogen, which constitutes so large a share of the gluten in the grain itself. Consequently every judicious farmer will aim to restore, in some form, an equal quantity of these substances back to the soil from which he has taken them.

But having already detailed, in the chapter on Inorganic and Organic Manures, the mode of preparing and applying all these substances, we will only repeat here the important truth, that in apply-

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From what are the best wheat lands originally derived? Will any soil bear long continued cultivation for the same crop without becoming exhausted? In the cultivation of wheat, of what ingredients does the soil become exhausted first? How much of these substances does every ton of wheat remove from the soil? What then will every judicious farmer do? What must guide us in the applicationof manure for wheat or any other crop?

ing manure we must in all cases be guided by the composition of the soil and the particular crop we wish to grow from it; and further, that the application of all inorganic manures, as lime, potash, soda, &c., will fail to produce their characteristic beneficial effects, unless the soil to which they are applied contains a sufficient quantity of decaying vegetable matter, on which they may act.

Hence, however desirable it may be occasionally to let a field lie in summer-fallow with an application of fifty or sixty bushels of air-slacked lime, or fifteen or twenty of unleached ash to the acre, yet we think experience will teach wheat-growers, as well as all others, that the cheapest, richest and most abundant source of both organic and inorganic manure is found in a mixture of the barn-yard litter, the solid and *liquid* excretions of farm stock, with a few bushels of lime, burned bones, plaster and ash, all well mixed and secured from the washing of rain, until spread over the ground just before the last ploughing preparatory for the seed. The great advantages of such a mixture, consist not only in the fact that it contains all the salts as well as carbon which the growing plants require, but the urine or liquid excretion holding the most important salts in solution, presents them in the most favorable condition for absorbtion by the roots of vegetables.

The ground being well prepared, the best time for sowing winter wheat is the last of September or first of October. Sown thus early, it gains a length of root and expansion of leaf, that renders it much

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When will the application of *inorganic* manures fail to produce benefit? How much air-slacked lime or unleached ash may be applied per acre on summer-fallow for wheat? What will experience yet prove to be the cheapest, richest, and most abundant source of both organic and inorganic materials for manure? In what do the great advantages of such a mixture consist? What is the best time for sowing winter wheat? Why?

less liable to be thrown out and killed by the frosts of winter, and it gains an earlier start in the spring. Sown at this time, one and a half bushels of seed are sufficient for the acre; but if not sown till later in the autumn, two bushels should be used.

Spring or summer wheat requires the same preparation of soils, and two bushels of seed to the acre —sown as early as the soil is dry enough in the spring.

When properly cultivated, wheat yields from 25 to 50 bushels per acre, and is one of the most valuable crops in the Middle and Western States. Although, owing to the very great neglect of manures, and particularly to liquid manure or urine, the average product of wheat in the United States does not probably exceed sixteen or eighteen bushels per acre, yet the total product of the present year is estimated at not less than 125,000,000 of bushels.

DISEASES OF WHEAT.

The principal diseases to which wheat is liable, are, rust, which consists in reddish powder, covering the stalk, and preventing its farther growth, and hence causing the grain to shrivel, or fail of reaching maturity; mildew or blight, which consists in a fungous growth from the stalk, resembling mould, and producing nearly the same effects as rust; and smut, which is a disease of the berry or kernel itself.

How much will then suffice for an acre? If not sown until late in autumn, how much should be used? When should spring wheat be sown, and how much seed per acre? How much of wheat may be obtained per acre by proper cultivation? How much is now the average produce per acre in the United States? What are the principal diseases of wheat? What is meant by rust? What by mildew or blight? What by smut?

The first two of these occur most frequently in the latter part of July, or during the first days of August, during *very warm* weather and frequent showers of rain, or very heavy dews. There are no known remedies to be depended on; but we would suggest whether much could not be done by rightly proportioning the organic or carbonaceous matter and the mineral ingredients in the soil, so that the straw shall not grow too rank and juicy for its firmness, as is generally the case where soluble carbonaceous matter exists in excess relatively to the salts or mineral ingredients, which give firmness and strength particularly to the outer covering of the straw.

The smut is a black morbid growth in the berry, which renders the flour black and unwholesome. It is said to be effectually prevented by soaking the seed in strong brine, sprinkling it with slacked lime while wet, and leaving to dry twenty-four hours before sowing. We should not be willing, however, to vouch for the infallibility of this remedy, though doubtless often successful. Beside these diseases, wheat is liable to be much injured by the Hessian-fly, the wire-worm, and the grain insect. But for an account of all these, we refer to Chapter First of the Appendix.

RYE.

The Secale Cereale, or rye, has long been cultivated for food, and is, in many of the colder parts of the temperate zone, one of the most profitable

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When do the first two of these most frequently occur? Under what circumstances do they generally occur? Are there any certain remedies? How might the composition of the soil be made to act as a preventive? What is meant by smut in wheat? How is it said to be prevented? Is this remedy infallible? What else is wheat liable to be injured by? What is the name of rye? In what parts of the earth is rye a profitable crop? For what is it used?

crops of the farmer. It is generally sown in September, and is ready for harvest the last of the following July or first of August. Little more than one bushel of seed should be sown on an acre.

All we have said in regard to the preparation of the soil for wheat is equally applicable to this crop, although rye will yield a profitable harvest from a much more sandy soil, and in a colder climate than is required for wheat. It is subject to fewer diseases and less liable to injury by insects than the former grain.

Almost the only disease to which it is liable, is the Secale Cornutum, or smut, which consists in a black or grayish fungous growth of the berry. This is sometimes very prevalent in the crop, and if not separated from the grain before grinding, not only injures the looks of the flour, but renders it positively unwholesome for food. Proper draining and ploughing of the soil, together with the same mode of preparing the seed as mentioned for wheat, would doubtless almost entirely prevent the growth of this substance. With judicious cultivation, rye yields from 30 to 60 bushels per acre, and is worth from 50 to 75 cents per bushel.

ZEA MAIZE, OR INDIAN CORN.

This is a native of this country, and was unknown until after the discovery of America. Since that im-

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At what time of the year is it generally sown? At what time is it ready for harvest? How much seed is required per acre? How should the soil be prepared for this crop? Under what circumstances may we get a profitable crop of rye and not of wheat? Is it as liable to injury from diseases and insects as wheat? What is the principal disease to which it is liable? Of what does this disease consist? What effect does it have on the flour when not separated before grinding? What would probably prevent this disease? How much rye may be grown on an acre? What is the proper name of Indian corn?

portant event, it has been cultivated extensively as an article of food in many parts of the world. It flourishes best in a light sandy loam, containing a good supply of vegetable matter and phosphatic salts. It is, perhaps, more than almost any other crop, benefited by thorough ploughing and free application of vegetable and animal manure, mixed with some of the salts of lime, particularly the phosphate and sulphate. It should be planted in rows, at least three feet apart, and not more than four or five kernels in a hill. The manure may either be spread broadcast on the field, before the last ploughing, or a small shovel full placed in each hill. If none of the salts of lime are mixed with the manure, a spoonful of sulphate of lime (plaster) or of burned and pulverized bones, should be applied on each hill about the time of the first hoeing.

Corn should be planted as early in May as the soil can be prepared properly, and have the young shoots escape the frosts, and well hoed two or three times during the season. It will make its appearance earlier, and be more vigorous, if the seed is soaked in a strong solution of muriate of ammonia, (sal ammoniæ,) or chloride of sodium, (common salt,) twenty-four hours before planting. In selecting corn for seed, those ears only should be chosen that are well filled out, and from stalks that contain at least two sound ears.

The best mode of harvesting, is to cut up the stalks at the bottom, as soon as the kernels become

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Of what country is the zea maize a native? When was it first known? What is its use? On what soil does it flourish best? What kind of ploughing and manure particularly benefit this crop? How should it be planted? How may the manure be applied? When no lime is mixed with the manure, what should be added to the hills, and at what time? When should corn be planted? How many times should it be hoed? What may be done to the seeds before planting with benefit? What precautions should be taken in selecting corn for seed? What is the best mode of harvesting?

hard, and place them together in bunches or shocks until dry. In this way the crop can be earlier removed from the field. It requires less labor, and saves much more of the stalks and husks for cattle-feed the succeeding winter. All heavy, wet soils are unfavorable for the cultivation of corn. And it will be readily seen, by turning to the table showing its composition, that it cannot flourish well in any soil that is not well supplied with phosphoric acid, potash and lime.

This crop is much exposed to injury from the wire-worm, which generally attacks it as soon as it rises a few inches above the soil. For an account of this and other worms injurious to the farmers' crops, see the chapter on that subject.

With good soil, and proper cultivation, 100 bushels of corn may be grown on a single acre. But owing to neglect, and ignorance of the best modes of preparing and applying manures, the average yield in this country does not probably exceed 30 or 35 bushels per acre.

OATS.

The Avena Sativa, or oats, are cultivated extensively in most parts of the world, as food both for man and animals. They constitute one of the most certain and profitable crops of the farm, growing on almost any cultivatable soil, and yielding from 30 to 80 bushels per acre. Less ploughing and less manure

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Why is it the best? What soils are unfavorable for the cultivation of corn? From what is this crop liable to injury? How much corn may be grown on an acre? How much is probably the average yield in this country? To what is this owing? What is the name of oats? Where, and for what is it extensively cultivated? What does the avena sativa constitute? What is the ordinary yield per acre? On what soils may it be cultivated with profit?

are required for this than for either of those species of grain to which we have already alluded.

But though oats are capable of yielding a reasonable harvest with less expenditure of labor and manure than most other kinds of grain, yet none are capable of greater improvement, or will better repay the application of such means. They should be sown in the latter part of April, or as early as the soil can be prepared after it becomes dry in the spring. Two bushels of seed should be applied to the acre. This crop is seldom injured by insects or worms.

BARLEY.

The Hordeum Vulgare, or barley, is used extensively as an article of food, and for the manufacture of malt and spirituous liquors. It requires a richer and better cultivated soil than oats, and yields an average of 30 bushels per acre. It is chiefly cultivated in the temperate zone. It is generally more certain to yield a good crop when sown after potatoes or turnips. It should be sown at the same time as oats, and requires three bushels of seed to the acre.

BUCKWHEAT.

This grain is also much cultivated in some countries for food, and in favorable seasons is a very

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Is it as susceptible of improvement by the application of labor and manure as the other species of grain? When should the seed be sown? How much seed is required per acre? Is this crop often injured by insects or worms? What is the common name of the hordeum vulgare? For what is barley used? What soil does it require as compared with the oat? In what part of the earth is it chiefly cultivated? How much is the average yield per acre? How much seed should be sown per acre? For what is buckwheat cultivated?

profitable crop. It flourishes well on any ordinary soil, and yields from 30 to 50 bushels per acre. It should be sown in the latter part of June or first of July. It is very liable to injury from variations in the season, and is therefore a very uncertain crop in our climate. If turned under with the plough, when the plant is in blossom, it forms an excellent green manure for fertilizing the soil preparatory to the growth of wheat or other crops. It is more liable to injury from excessive warm weather during the formative or soft state of the kernel, than from any other cause. Hence it is sown late, that the greatest heat of summer may pass before the grain arrives at the period when it is liable to injury from that source.

PEAS.

When cultivated as a field crop, peas should be sown early in the spring, on a light, dry soil. They are much cultivated, both in the garden and the field, and are much esteemed as food for man and animals. The seed will germinate quicker and more certainly if soaked in water, or a solution of salts, a few hours before sowing.

BEANS.

There are many varieties of the bean, which are cultivated like the pea, both in the garden and the field. They are planted in hills like corn, and afford to the

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On what soils does it flourish? How much will it yield per acre? When should it be sown? What makes it an uncertain crop? How may it be made a valuable fertilizer for the growth of wheat or other crops? From what is it most liable to injury? Why is it generally sown late? When the pea is cultivated as a field crop, at what time should it be sown? How is the pea cultivated and for what purpose? How may the seed be made to germinate quicker? Is there more than one variety of the bean? How are they cultivated?

farmer a very valuable crop, because they may be grown abundantly on fallow grounds and places too much exhausted for other kinds of grain. They are best adapted, however, to a light, gravelly soil; and the middling-sized white variety is most esteemed. They may be planted at any time during the month of May, or even as late as the first week in June. Four or five seeds should be planted in a hill, and, like corn, they should be hoed two or three times during the season, to keep the soil loose or porous and free from weeds and grass. Perhaps no crop is more benefited by the application of sulphate of lime or plaster than this. It should be applied to the hills at the time of the first hoeing, at the rate of one table-spoonful to a hill.

ROOT CROPS.

POTATOES.

The Solanum Tuberosum, or potato, is probably the most valuable of all roots, and is cultivated extensively in almost all civilized countries, as food for man and animals. Like many other cultivated crops, there have been formed several varieties, some of which grow wild in some of the mountainous districts of South America. They flourish best in a light sandy loam, well supplied with vegetable matter; although they yield a fair crop on almost any well cultivated soil, especially when turned over

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On what soils may they be grown abundantly? What soils are best adapted for their cultivation? What variety is most esteemed? When may they be planted? How much seed should be put in a hill, and how often do they require hoeing? What substance is particularly beneficial to this crop? How should it be applied and in what quantity? What is the name of the potato? Which is the most valuable of all the root crops? For what is it used? Where does it grow wild? In what soil do they flourish best?

as green sward. They are much benefited by well-prepared manure, thoroughly mixed with the soil before planting.

The best mode of preparing the seed for planting, is to cut off the seed end, or that part of the potato in which the eyes are thickest, and planting two of these ends in a hill, leaving the rest to feed to the farm stock. The hills should be planted in rows, three feet apart, and the seed covered from three to five inches deep, according to the moisture of the soil.

Potatoes, like corn, require ploughing and hoeing two or three times during the season, to keep the soil loose and free from weeds and grass. When the crop has come to maturity, the tops become dead and dry. As soon as this takes place, the potatoes should be dug and placed in cellars, or in pits large enough to contain from 25 to 50 bushels, and covered with straw, over which dirt must be thrown thick enough to protect them against the frosts of winter. A very small hole, however, should be left at the top for the ingress or egress of air.

Potatoes will yield from 100 to 400 bushels per acre, and generally sell for two or three shillings per bushel. They may also be propagated by planting the seeds, which are borne on the tops of the vines.

The yam, or sweet potato, flourishes best in the southern part of our country, and, indeed, in all warm latitudes; but will not come to maturity in the

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By what are they much benefited? What is the best mode of preparing the seed for planting? How should they be planted? When should they be dug? How should they be preserved? Why should a small opening be left at the top of the heap? How much may generally be obtained per acre? How else may the potato be propagated? Where does the yam or sweet potato flourish? Will it come to maturity in the Northern States?

Northern States without great care. There is nothing peculiar, however, in its cultivation.

Diseases.—The potato has usually been regarded as one of the most certain crops of the farm, and one the least liable to diseases; but for three or four years past this crop has been almost entirely destroyed in this and the adjoining States, by a disease which kills the vines before the potatoes come to maturity, and causes them to decay very rapidly.

The nature of this disease is still a subject of controversy. Some contend that it is caused by an insect, which deposits its larvæ or eggs on the vines about the first of August, and which soon forms a maggot or worm, that penetrates the vine, severing the vessels that circulate the sap or juice of the plant, thereby cutting off its nourishment, and causing the leaves to assume at first a shriveled or crisped appearance, and then to become entirely dead. And some observations would seem to show that the worm penetrates even into the potato itself.

Others have attributed it to a kind of rust or fungus, somewhat similar to the rust in wheat. And others again have promulgated the theory that this useful vegetable is about to disappear and be lost, from a natural tendency to decay. The truth is, the nature of the disease, as well as an effectual remedy, is still a problem. The only remedy which we have seen represented as effectual, is the placing of a little lime in the hills, or sowing it on the vines about the time they are in blossom. We have no doubt that the efficacy of the lime would be much increased by mixing it with salt, in the proportion of two

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Is there anything peculiar in its cultivation? What has happened to the potato crop during the last few years? Is the nature of the disease well known? To what has it been attributed? Is there any known remedy to be relied on? What has been represented as effectual by some? How might its efficacy be increased?

parts of lime to one of salt, and applying it in the hill.

TURNIPS.

The cultivation of turnips as a field crop is of recent date, and is regarded by many as marking an important era in the progress of agriculture. There are several varieties cultivated, the most important of which are the yellow, the white, and the ruta baga, or Swedish turnips. The last of these yields the most bountiful crop, and is the principal variety cultivated in the field. They will not thrive on a wet or very clayey soil.

The turnip derives much of its nourishment through its large and juicy leaves, and its root penetrating the soil to a considerable depth divides and loosens it in such a manner as to leave it in a very favorable condition for the succeeding crop. The best mode of preparing the soil, is to manure it well with good vegetable and animal manure; plough it deeply and very fine, and sow the seed in rows two and a half feet apart. Half a pound of good plump seeds to the acre will produce plants enough if they germinate well. But it is safer to add more seed, and if the plants appear too thick, pull them out. They require frequent hoeing to keep the soil light and free from weeds.

From 500 to 1000 bushels of ruta bagas may be obtained from a single acre, and the ground on

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Has the turnip been long cultivated as a field crop? Is it regarded as of much importance? Which are the most important varieties cultivated? Which yield the most bountiful crop? On what soil will they not thrive? Through what parts does the turnip derive much of its nourishment? Why does the turnip leave the soil in a favorable condition for other crops? What is the best mode of preparing the soil for this crop? How much seed should be applied to the acre? How should the seed be sown? What do the plants require? How much may be obtained from an acre? In what condition is the soil left?

which they grow be better prepared for a good crop of wheat, or other grain, than before the turnips were sown. They are of great value as food for farm stock, and may be sliced raw and fed in the same manner as potatoes, a little salt being sprinkled on each mess.

The time of sowing the seed is between the 25th of June and the 15th of July. The turnips should be gathered before any severe injury by frosts, the tops and tap-roots cut off, and the turnips stored in cellars, or pits three or four feet wide, and well covered with straw and earth, in the same manner as directed for potatoes. The white and yellow varieties may be cultivated in the same manner as the ruta baga; but they are less productive, and less valuable for food.

When the turnip plant is very young and tender it is very liable to injury by insects. This may be prevented in a great measure, by scattering over and around the young plants a mixture of air-slacked lime and salt or ash, being careful not to apply so much as to kill the plants themselves. See chapter on insects.

BEETS.

Several varieties of this excellent root have long been cultivated. The mangel wurtzel is the largest and most productive variety, and the only one cultivated extensively for food in this country, as a field crop. The soil and mode of cultivating this crop

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For what are they valuable, and how should they be fed? What is the usual time of sowing the seed? When should they be gathered, and how kept? From what are turnip plants liable to injury? How may injury from this source be prevented? What caution is necessary? Is there more than one variety of the beet? Which is the largest and most productive? In what respect does the cultivation of the mangel wurtzel differ from the ruta baga?

may be the same as that recommended for the ruta baga. The beet, however, requires a richer soil, and the ploughing must be at least twelve or sixteen inches deep and very fine. This variety of beet generally yields nearly the same per acre as the ruta baga, and may be gathered and preserved in the same way. They are chiefly used for feeding farm stock.

The turnip and blood beets are chiefly cultivated in gardens for culinary use. The white, or sugar beet, is extensively cultivated in some countries, not only as food, but for the sugar which it contains. France has nearly supplied herself with sugar from this kind of beet, during the last few years. It is now cultivated to some extent in our country, and is a very valuable crop, yielding nearly as much per acre as the mangel wurtzel. The sugar beet requires a good soil, well manured, and cultivated in the same manner with other beets.

All varieties of the beet should be sown one month earlier than turnips. When used for making sugar, the juice is pressed out and boiled until crystallization begins to show itself, and then cooled in cakes and clarified, or rendered white and pure in the same manner as other varieties of sugar.

CARROTS, PARSNIPS AND ARTICHOKES.

These are also among the root crops that have long been cultivated in gardens, and which might

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Which requires the richest soil? For what purpose is this variety of beet chiefly raised? What varieties are cultivated in gardens, and for what purpose? For what is the sugar beet cultivated extensively in some countries? In what country has this been done to a very great extent? Is it cultivated for the same purpose in this country? Does its mode of culture differ from the other varieties of the beet? At what time should all the varieties of beet seed be sown? In what way is sugar obtained from the beet? What other root crops might be profitably cultivated in the field?

be sometimes profitably extended to the field. But their mode of culture and use so nearly resembles that of the turnip, that a separate description is not necessary.

With the exception of the potato, the cultivation of roots has received far too little attention by agriculturists in this country. They are not only among the most valuable crops for food, but they form a most important link in every judicious system of *rotation* adopted for the improvement of soils. Their mode of culture necessarily pulverizes the soil to a considerable depth, which, together with the manure that is generally added, leaves it in excellent order for a succeeding crop of wheat, corn or rye.

GRASSES AND CLOVER.

The various grasses constitute the principal food for farm stock, and hence, in all cold countries, their cultivation is of the first importance. The varieties of grass are very numerous, and much difference exists in regard to their relative value. Some kinds are better adapted to some soils than others. Hence particular attention should always be paid to the selection of seed, and the kind appropriate to the particular soil to which it is to be applied. The varieties most valued in this country are timothy or herds grass, red-top, tall oat grass, and clover.

TIMOTHY OR HERDS GRASS.

This is a hardy perennial species, growing abundantly in temperate climates, and very luxriantly on

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Why is a separate description of their mode of culture, &c., unnecessary? Why are root crops particularly valuable in every system of farming? What do the various grasses constitute? In what countries is their cultivation important? Is there much difference in the relative value of different varieties? What are the varieties most valued in this country? What are the characteristics of timothy or herds grass?

almost all our soils. It is the principal grass relied on for hay in all the Northern and Middle States. It flourishes best on moist, loamy soils. The best time for cutting it, is soon after the flowering season, and while the seed is soft, or "in the milk." When cut at this season, it exhausts the soil much less than if the seed is allowed to ripen, and is equally good or better for hay. It should be cured by spreading it in the sun until wilted, and then allowing it to stand in bunches over night.

To obtain seed, the grass must be allowed to fully ripen, and then the tops may be cut with a sickle or cradle ten or twelve inches down. This must be dried in the sun, and bound up and threshed like grain. The bottom part may still be mown and saved for hay. Four or five pounds of seed should be sown on an acre, either with winter grain in the fall, or with spring grain early in the spring. The seed should be covered with a light brush harrow.

RED-TOP.

This species of grass is a native in the Middle and Southern States, and is very valuable both for meadows and pasture. It grows very luxuriantly on low wet lands, and is found in most meadows mixed with herds grass. Its cultivation is in all respects similar to that described for the latter variety of grass.

TALL OAT GRASS.

This variety of grass has hitherto received but

What variety is principally relied on for hay in all the Northern and Middle States? On what soils does it flourish best? What is the best time for cutting it? Why? How should it be cured? How can the seed be obtained? How much seed is required per acre? When may it be sown? Where is the red-top a native? For what is it valuable? On what soils does it grow most luxuriantly? Has the tall oat grass received much attention in this country?

little attention in this country; but it is considered by Mr. Taylor, and some others, as the best of all the cultivated grasses. It grows very rapidly, and ripens early. Hence it is well adapted for pasture. Six pecks of the seed may be sown on an acre of grain crops in the spring. It grows best on moist clay soils.

CLOVER.

Only two kinds of clover are cultivated to any considerable extent in this country—the common red clover, and the cow grass or short clover, which ripens earlier and allows of two crops in one season. Besides these, the white clover, which is found abundantly in pasture lands, is a very valuable variety, and should receive more attention.

Clover is better adapted to light, sandy and dry soils, than any other variety of grass. On such soils its roots often penetrate to a great depth, and produce a very abundant crop, without much exhausting the inorganic ingredients of the soil. Hence its great value as a preparatory crop for wheat and other grain.

The best time for sowing is early in the spring, with either winter or spring grain. From six to ten pounds of seed should be sown on an acre. It should be cut for hay when in full blossom, and wilted in the sun, then gathered into cocks or bunches, and allowed to stand one or two days.

How is it considered by Mr. Taylor? What are its advantages? How much seed should be sown per acre, and when? On what soils does it grow best? How many kinds of clover are cultivated in this country? What is the difference between them? What kind of clover is found in pasture lands? What kind of grass is best adapted to light, sandy soils? Why is it valuable as a preparatory crop for wheat and other grain? What is the best time for sowing the seed? How much is required per acre? When should clover be cut for hay? And how should it be cured?

After this, they should be opened freely to the sun again for a few hours, and then gathered into the barn. It will be much benefited by sprinkling a few pounds of salt in the mow.

Clover cut while in blossom, makes better hay, and exhausts the soil much less than if allowed to stand until fully ripe; but being a biennial plant, it soon gives place to other varieties of grass in meadows. The best seed is obtained from the second growth, which ripens about the first of September. Sulphate of lime, or plaster, is an excellent manure for this crop, and should never be neglected.

Such are the principal varieties of grass worthy of attention. The clover is chiefly cultivated as an improving crop, to prepare the soil for other grains. For this purpose it is often turned under with the plough while in blossom, instead of being mown for hay. All permanent grass fields, whether for meadow or pasture, should be annually sown over with lime, plaster and ash, alternately.

Sect. 4. *Rotation of Crops.*

Few things have contributed more to the improvement of agriculture than the introduction of a system of change or rotation of crops. The old method of dividing off one part of the farm for permanent pasture, another for meadow, and a third for continued cultivation, was found by long and sad ex-

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What may be sprinkled through the mow or stack with benefit? Why should clover be cut when in blossom for hay? Why does it soon run out or give place to other kinds of grass? How is the best seed obtained? What constitutes an excellent manure for clover? For what is clover chiefly cultivated? How is it often treated? What should be done to all permanent grass fields? What is meant by *rotation* of crops? What objection is there to letting one part of the farm remain as permanent meadow, another pasture, &c.?

perience to lead invariably to barrenness and exhaustion.

This result is produced by the continued removal from year to year of the same organic and inorganic ingredients, until they are so far exhausted that they will not afford the plant sufficient nourishment to bring it to perfection. And hence it must be allowed to lie waste or uncultivated one, two or three years, for the slow process of disintegration, to replenish it with these deficient materials.

This effect is well illustrated in the older cotton and tobacco growing States of the South, where whole plantations have been exhausted from repeated crops of these great staples; and where nothing but the free application of manure, and a judicious system of rotation, is required to restore a high degree of fertility.

Every rational system of rotation or change of crops is founded on the well ascertained fact, that different species of plants take from the soil different ingredients, or different quantities of the same ingredients. This difference is well illustrated by the following table, viz:—

	Salts of Potash and Soda.	Lime & Magnesia.	Silica.
Wheat straw,	9.00 per cent.	9.30	81.77
Corn stalks,	24.00 "	8.00	50.00
Rye straw,	18.65 "	16.52	64.50
Oat straw,	15.18 "	3.13	79.93
Pea straw,	27.82 "	63.74	7.81
Potato herb,	4.20 "	59.40	36.40
Clover,	39.20 "	56.00	4.00
Turnips,	81.60 "	12.00	
Beet root,	88.00 "	11.50	
Potatoes,	85.81 "	14.19	

In what sections of the country are the injurious effects of such a system well illustrated? What is there required to restore the fertility of the soil? On what is every rational system of rotation founded? In what crops do the salts of potash and soda predominate? In what the lime and magnesia? In what the silica?

It will be seen by the foregoing table, that all the crops of the farm may be arranged into three classes. The first, comprehending the grains wheat, rye, oats, corn, barley and rice, contain silica as their predominating inorganic ingredient; the second, embracing pea straw, potato, cotton and clover, contain only a very small proportion of silica, and a large proportion of lime and magnesia; while in the third class, including the root crops, as turnips, beets, carrots, potatoes, (tubers,) there is a large proportion of potash and soda, with only a small quantity of lime and magnesia, and no silica.

Hence it is evident that if these classes of plants are cultivated successively, or in rotation, on the same soil, each will rely in a great degree on different inorganic ingredients from the one which has preceded it; and consequently the soil will be much less rapidly exhausted than if the same crop, or one belonging to the same class, were applied every year.

What we here deduce from the composition of different crops, is confirmed by the experience of the best farmers. Thus we may take, 1st, a crop of potatoes and corn, applying a liberal quantity of good compost or barn-cellar manure; 2d, wheat, with lime in some form; 3d, barley or oats, with peas; 4th, roots, as turnips, beets, potatoes, &c., with a full coat of compost or barn-cellar manure and ash; 5th, wheat again, with clover seed if the soil is light and sandy, and herds grass if clayey. It should now remain either in meadow or pasture two or three years, with the annual addition of ash, plaster,

How then may all the crops of the farm be divided? What will be the effect of cultivating these classes successively or in rotation on the same soil? With what does this rule, deduced from the composition of vegetables, correspond? What particular crops may be made to succeed each other with benefit, and in what manner?

or charcoal pulverized ; after which the same system of rotation may be commenced again. In the Southern States a crop of cotton, rice or tobacco, may be substituted in the place of each wheat crop.

With such a system of rotation and manuring, any and every farm, instead of wearing out, will become more and more fertile from generation to generation. But it should be remembered, that the best system of rotation, without manure, may indeed retard, but can never prevent final exhaustion and barrenness.

Again, a judicious rotation of crops necessarily implies also a rotation of fields. That is, of the various fields into which the farm is divided, each one should be used alternately for cultivation, pasture and meadow. It is often objected, that a part of the farm is too wet for cultivation, and must therefore remain continually for meadow or pasture; and, as a necessary consequence, the rest of the fields must be constantly tilled. But a field too wet for cultivation, is also too wet for profitable grass land, and should therefore be drained, if practicable, and placed in the proper rotation.

The truth of what has been said in the preceding pages in regard to the preparation of soils, manures, rotation of crops, &c., is generally assented to; but still entirely neglected on account of its requiring so much expense. No more fatal error exists among agriculturists than this. It is true, that the mode of cultivation proposed would require more labor and expense per acre than the old mode of always

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What will be the result of such a system of manuring and rotation ? Will any system of rotation alone prevent exhaustion of the soil ? What does a judicious system of rotation of crops necessarily imply ? What do you mean by rotation of fields ? What should be done with a field too wet for cultivation ? What objection is generally urged against the foregoing views of farm cultivation ?

ploughing the same fields as long as anything will grow on them, and then letting them lie barren until they have partially recovered. But it is equally true that the value of the crops will be increased in a two-fold greater ratio than the labor and expense.

Thus, Mr. Young found, by actual experiment, that a soil which in its natural state would produce 280 bushels of potatoes per acre, would, by the addition of 32 cubic yards of stable manure, produce 400 bushels per acre; and if the same quantity of barn-cellar manure, which is well charged with urine, was used, the quantity was increased to 520 bushels per acre—making a net increase, by the latter kind of manure, of 240 bushels per acre; which, at 25 cents per bushel, would amount to sixty dollars; a sum sufficient to defray all the expense of preparing and applying the manure for five acres instead of one.

But this is not all; for if wheat is now sown on this ground, after the potatoes are removed, 30 or 40 bushels per acre may be harvested instead of 15 or 20, as would be the result without the previous manuring. Indeed, but few agriculturists realize how much may be obtained from a given quantity of soil by scientific management. Hence, a few examples may be profitably introduced here. A well-managed farm of forty acres, near Lancaster, Pa., has produced in one year—

5	acres of corn,	- -	300 bushels.
10	" wheat,	- -	340 "
5	" oats,	- -	300 "

How is the increase of labor and expense per acre doubly repaid? What did Mr. Young find by actual experiment? How much was his crop increased by the application of barn-cellar manure? What other benefits resulted besides the great increase of the present crop? How much corn was produced on five acres of a farm near Lancaster, Pa.? How much wheat per acre?

5 acres of	rye,	100 bushels.
10 "	hay,	30 tons.
5 "	pasture.	

This, at the usual market value, would amount to near $1000, which is at least one-third more than is generally taken from the same quantity of good land by ordinary management.

Mr. Jenkins, of Kent, in the State of Delaware, in 1837 took from thirty-eight acres of what was originally a very poor, light soil, the following products, viz:—

Oats,	250 bushels.
Wheat,	196 "
Corn,	325 "
Clover hay,	35 tons.
Wheat and oat straw,	15 "
Irish potatoes,	140 bushels.
Sweet "	15 "
Turnips,	40 "
Pasture for	4 cows.

All this, at the prices of that year, was worth $1,692, equal to the interest on a capital of $20,000. In 1833, Mr. Hoyt, of Deerfield, Mass., averaged a still greater yield from three and a half acres of land.

Again, Mr. J. J. Thomas, in his Essay on Farm Management, gives the following product of fifty acres of judiciously cultivated land, viz:—

10 acres of	wheat,	35 bush. per acre,		350 bush.
5 "	corn,	90 "	"	450 "
2 "	potatoes,	300 "	"	600 "

What was the market value of the produce of the whole 40 acres for one year? What was the value of Mr. Jenkins' crop in 1837 from only 37 acres of land? What was the original character of his soil? Who averaged a still larger yield in 1833, in Massachusetts? What does Mr. J. J. Thomas give as the average yield of 50 acres of judiciously cultivated land?

1	acre of	ruta baga,	800	bush.	per acre,	800	bush.
6	"	winter apples,	250	"	"	1,500	"
5	"	barley,	40	"	"	200	"
5	"	oats,	50	"	"	250	"
6	"	hay,	2 1-2	tons	"	15	tons.
10	"	pasture.					

The whole making a value of not less than $1,400. When we remember that the great difficulty of the farmer is to pay for his 100 or 200 acres of land, and reflect that 50 acres, properly managed, will produce more than the whole 100 cultivated in the ordinary way, the subject becomes one of very great importance.

SECT. 5. *Connection of Farm Stock with Vegetation.*

The observations contained in the preceding pages, in regard to the various kinds of manure, will suggest the close connection which exists between the farm stock and the farm produce. Much has been said about the relative merits of different breeds of cattle, sheep, horses, &c., but we think one important fact has been entirely overlooked. That is, the quality of any species of stock depends far more on the *manner* in which it is kept, than on the particular breed. For the rule, that every species of animals and plants degenerates by bad or scanty food, and severe exposure to cold and storms, and improves by good care and plenty of good food, will be found *invariably true.*

Hence the true method of improving farm stock, is to improve the farm in such a manner as to afford

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In what aspect is this subject of great importance to the American farmer? Is there any necessary connection between the farm stock and the farm produce? On what does the quality of any species of stock principally depend? How may any species of animals be degenerated or improved? What then is the best method of improving farm stock?

them a variety of the best food, and good stables or warm shelter. To effect this, a great variety of root crops should be cultivated and preserved in good order. It is comparatively of little consequence that this breed or that is imported from abroad at a heavy expense; for so sure as they are but half fed and half cared for, they will soon degenerate and become no better than our own native kinds.

Sect. 6. *Selection, Preservation and Preparation of Seeds; and the Propagation of Plants by Cuttings, Layers, Buds, Grafts, &c., &c.*

SELECTION AND PRESERVATION OF SEEDS.

No one thing about the farm or garden requires more care than the selection of seeds; for it is well known, that every variety of plants may be altered in their qualities, improved or degenerated, made earlier or later, and more or less fruitful, by a selection of seeds. Hence a few simple rules of much importance may be given here.

1st. All seeds should be allowed to ripen fully before they are gathered, and then all the withered and imperfect ones should be separated, retaining only such as are perfect and healthy. And these should be kept dry.

2d. If it is desirable to make the plant *earlier*, those seeds only should be saved that ripen first. This done for two or three years in succession, will materially shorten the time required for the plant to arrive at maturity. This rule is of great importance

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What species of crops are particularly valuable for that purpose? What will soon become of the best foreign breeds if they are only half fed and half cared for? How may plants be altered in their qualities, or rendered earlier or later? When should all seeds be gathered, and how preserved? How can a plant be made earlier?

in cold countries, where the season of vegetation is short.

3d. If we wish to make any species more fruitful, without reference to the time required for attaining maturity, the seeds should be saved only from the largest and most perfectly filled heads, ears or fruit. Thus, every farmer knows that a selection of only eight-rowed corn for seed, will propagate the same; and so of every other variety.

4th. The whole may be comprehended in one proposition, viz: that every seed tends to produce its own like. A knowledge of this single fact will always enable the farmer to change, or improve, or multiply his species of produce almost without limit. But two, three or more years are required to effect a marked change in any respect. Hence too much care cannot be exhibited in the selection of seed for farm or garden crops.

PREPARATION OF SEEDS.

During the last year or two much has been said about the benefits to be derived from the soaking of seeds in various chemical or saline solutions, such as the nitrate, sulphate, and muriate of ammonia; nitrates of soda and potash, and in combinations of these.

Indeed, so exaggerated were some of the early reports on this subject, that not a few were almost induced to believe that the mere soaking of their

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In what countries is this important? How can any species be made more fruitful? What single proposition comprehends the whole? What will a knowledge of this single fact enable the farmer to do? How long a time is required to effect a marked change in this way? What then is requisite in the selection of seeds either for the farm or garden? What has attracted much attention in regard to the preparation of seeds? What substances have been used for soaking seeds? What was the character of some of the early reports on this subject?

seeds would remedy the necessity of manuring their soil. And we were told to continue the soaking from fifty to ninety hours, at a temperature of 68° Fahrenheit. But more extended and careful experiments have well nigh banished all these bright anticipations.

There is no doubt, however, that soaking of seeds in very dilute solutions of these salts, or in water alone, for twenty-four hours before planting, will cause them to grow quicker and more vigorously. And if, after being soaked, they are rolled in lime or plaster, the benefit will be considerably increased. Such treatment may also serve, in some slight degree, as a protection against worms.

From numerous experiments, we are also induced to believe that thoroughly washing seed wheat in a solution of common salt, rolling it in plaster or lime, and drying it before sowing, is an effectual mode of preventing smut in the future crop. And if it will prevent the smut in wheat, we see no reason why the same treatment will not prove equally efficacious when applied to seed corn, oats, rye, &c.

PROPAGATION OF PLANTS.

The propagation of plants by cuttings, layers, grafting and budding, relates rather to the propagation of fruit trees than to ordinary farm produce. Hence but little space will be devoted to their consideration.

Cuttings.—This mode of propagation consists in simply placing a slip, or branch of the plant or tree, containing on it one or more buds, in a well pulver-

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What has been the effect of more careful and extended experiments? In what, and how long may seeds be soaked with benefit? What will much increase this benefit? What treatment applied to the seeds will prevent the smut in grain? In what ways may plants be propagated without using seeds? How are plants propagated by cuttings?

ized and mellow soil. Care should be taken that one or more buds on the slip are placed deep enough to be kept constantly moist. In a little time roots shoot out around the base of the bud, while the rest sends up a germ to become the future stalk, or stem. Slips designed for cuttings should be taken from the parent tree or plant either in the autumn or before the buds begin to swell in the spring. If they are taken in the autumn they must be kept from freezing, either in dry cellars, or buried in sand.

Layers—Only differ from cuttings, in being placed in a different position in the soil.

Grafting.—This is a very frequent and useful mode of propagating shrubs and trees. The most common mode is to cut off the branch or stem to be grafted, horizontally, split it through the centre, whittle one end of the slip or scion, obtained in the same manner as for cuttings, into a wedge shape, and insert it in the split of the stem, in such a manner that the bark of the slip or scion corresponds precisely with the bark on the stem ; then cover the cut surfaces with a soft, tenacious mass, made of resin, bees-wax and tallow, melted together. The sap in the bark and liber, or alburnum of the stem, is carried on into the same parts of the scion or slip, and thus its life is maintained ; it sends forth its leaves and branches ; and the process of nutrition soon unites it firmly with the main stem or trunk.

One great advantage of this mode of propagation is, that fruit is obtained several years earlier than

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What should the slip or cutting contain, and how deep should it be planted ? From what part of the slip do the roots proceed ? At what time should the slips designed for cuttings be taken from the parent tree ? If taken in the autumn, how may they be preserved until spring ? How do *layers* differ from cuttings ? What is the most common mode of grafting ? How is the life of the slip or scion maintained ? What is the principal advantage of this mode of propagation ?

from the seed. There are two or three other modes of grafting, but the essential object in them all, is to bring the bark of the scion and that on the stem closely in contact. And for that purpose, perhaps the mode which has been suggested is as convenient and successful as any.

Budding.—This process consists in making an incision in the bark of the stem to be budded, in the shape of a capital T, loosening up the bark a little way from the edges of the perpendicular incision, so as to make a triangular space ; then take a *bud*, connected with a piece of bark in such a shape as to *fit* the space just described, and insert, with the point of the bud upward. The loose edges of the bark on the stem overlap the edges of that attached to the bud, and the whole is retained in its place by a ligature or string.

The best time for budding is, whenever the bark is loose so as to be easily separated from the wood. The explanation is the same in this process as in grafting. The circulation of sap is continued from the bark of the stem to that of the bud. And the method is in some respects preferable to that of grafting.

CONCLUSION.

" There is no profession," says Liebeg, " which can be compared in importance with that of Agriculture, for to it belongs the production of food for

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Are there any other modes of grafting ? What is the essential object in them all ? How is the process of budding generally performed ? What is the best time for budding ? What are the relative merits of grafting and budding ? What great and important interests depend on agriculture ?

man and animals; on it depends the welfare and development of the whole human species, the riches of states and all commerce. There is no other profession in which the application of correct principles is productive of more beneficial results, or is of greater and more decided influence." A *truer* sentiment than this was never penned by man.

And we may add, that in no profession or employment is scientific knowledge of more value, or susceptible of more ready practical application. Indeed, it will be seen by the reflecting mind, that almost every act of the agriculturist is but the performance of an interesting chemical or scientific process. And hence the very prevalent idea, that a knowledge of reading, writing and arithmetic, is sufficient for a farmer, is as absurd as to suppose a knowledge of algebra sufficient to make a man a skillful physician. The great and varied benefits to be derived from higher scientific attainments by those engaged in the noble occupation of cultivating the soil, would afford a fruitful theme for a separate volume; and cannot even be touched upon here.

We must conclude, then, by simply expressing the hope, that the time is at hand when it will be deemed of more importance to teach the youth in our *schools* the composition of our soils and vegetables, and the most scientific mode of cultivating the bread which they eat, than simply enough of arithmetic to cipher out how much a few loaves would amount to at a shilling a loaf.

In what profession or employment is scientific knowledge of more value? Is there any way in which such knowledge is more directly applicable in practice? Of what does almost every act of the agriculturist consist?

APPENDIX.

CHAPTER I.

INSECTS AND WORMS INJURIOUS TO VEGETATION.

There are a great variety of insects and worms which occasionally infest the fruit trees and the crops of the farmer in such numbers as to prove very destructive to both. The most important of these are the Cecidomyia Tritici, or wheat fly; the Cecidomyia Destructor, or Hessian fly; the Curculio, or Calandra Granaria, or weevil; the Phalæna Noctua Devastator, or cut worm; the Gortynea Zea, or spindle worm of corn; Elator Lineatus, or wire worm; Galeruca Vittata, or striped cucumber bug; Haltica Pubescens, or cucumber flea; Aphides, or plant lice; Clisiocampa Americana, or apple tree caterpillar; Phalæna Vernata, or inch worm, or canker worm; Coccus Arboreum Lineatus, or bark louse; Saperda Bivittata, or apple tree borer; Carpocapsa Pomonella, or apple worm; Scolytus Pyri, or pear blight; Curculio Pyri, or pear weevil; Rhynchænus Nenuphar, or plum weevil; Ægira Exitiosa, or peach borer; and Clytus Pictus, or locust borer.

The three first named commit their ravages on

What sometimes infest the fruit trees and crops of the farm? What are some of the most important of these insects? What ones commit their ravages on the wheat crop?

the wheat crop, the six next on the corn and garden vegetables, and the remainder on fruit and fruit trees. And whether we view the remarkable changes which they undergo, their vast numbers, or the incalculable amount of property which they annually destroy, we find them equally objects of intense interest and importance; objects which should engage the careful attention of every farmer and gardener.

CECIDOMYIA TRITICI.*

This insect, commonly called the wheat fly, belongs to the class of insects called Dipterous, of the Cecidomyia species, and may be described as follows, viz: *head*, of a flattened-globular form; eyes large, covering two-thirds of the whole head, of a deep black color, appearing, when viewed in front, like a broad black band around the head; the face pale yellow, with two prominences on which the antennæ are inserted. The last are of a dark brown, about the same length with the body, and composed of twelve joints in the female, with a double row of hairs at each joint, and twenty-four in the male. The palpi are pale yellow, covered with shortish hairs, and composed of four oval joints. The *thorax*, or chest, is of a pale yellow color, slightly tinged with brown on the upper surface; of an ovate form, its vertical diameter much exceeding its transverse, as is common in this species, owing to the jutting down of the breast. The *poisers* are also yellow,

* See Plate I.

Which attack the corn and garden vegetables? Which are some of the most important that attack the fruit and fruit-trees? In what respects are they both interesting and important? What is the proper name of the wheat fly? To what class does the Cecidomyia Tritici belong? Can you describe it? How many joints in the antennæ? What is the color and form of the *thorax*?

Fig. 1. Cecidomyia Tritici greatly magnified; and also the fly in its natural size.

Fig. 2. The Male of Cecidomyia Tritici.

Fig. 3. Pupæ or worms of the wheat fly, as they appear on the soft wheat kernel.

Fig. 4. Pupa or worm of the Cecidomyia Tritici greatly magnified.

oval, and their pedicels strongly notched in the middle of their anterior sides. The *abdomen* is of an orange-red color throughout; scarcely equal in size to the thorax; attenuated towards the tip, with two valvular sheaths, between which the ovipositor may be protruded. The *wings* are hyaline and colorless, but reflecting various colors, particularly the violet, when viewed in certain directions. Their margins are densely covered with longish hairs; and when the insect is at rest, they are laid upon each other, horizontally, on the back of the abdomen, and reach about one-fourth of their length beyond it. The *legs* are long, slender, cylindrical, and of a whitish color. All parts of the body and limbs are clothed with minute, slender hairs.

The male fly differs from the female principally in the much greater length of the antennæ, and the less ovate form of the abdomen. It is also somewhat smaller in size. The wheat fly varies in size from the twelfth to the sixteenth of an inch in length.

Another fly, called the Cecidomyia Caliptera, is almost invariably found associated with the one we have just described. It differs from the Tritici, principally in having seven dark spots on each wing, which may be readily seen with the naked eye. But as its character and habits seem to be the same, a separate description is unnecessary.

We may observe, however, that Dr. Fitch, in a late number of the American Quarterly Journal of

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What is the color of the abdomen, and what does its tip contain? What is the appearance of the wings? With what are all parts of the insect clothed? How does the male fly differ from the female? What is usually the size of the wheat fly? What insect is usually found associated with the Cecidomyia Tritici? In what respect does it differ from the Tritici? Why is not a separate description necessary? What has Dr. Fitch observed in regard to the spots on the wings?

Agriculture, says that the spotted winged wheat fly which he has examined in this country has but six spots instead of seven, and hence he proposes to call it a Cecidomyia Cerealis, instead of Caliptera.

History of the Wheat Fly.—The insects here described, although well known in Europe many years previous, did not make their appearance in this country, in numbers sufficient to attract attention, until 1828, when they began to do much injury to the wheat crop in the northern part of Vermont, and the adjoining districts of Canada. They annually spread themselves east and west, at the rate of about fifteen miles each season. And they are now to be found, doing much injury, throughout the greater part of New-York and New-England.

The fly generally appears in the month of June, about the time wheat is usually in blossom. It continues only a few weeks, during which time it deposits its eggs, and disappears.* It may be most easily detected by examining the wheat field after sundown, or in the evening, at which period the insect is most lively, and often appears in immense swarms around the wheat-heads, depositing their eggs within the chaff which is to surround the future grain. At this time, any number of them may be caught by passing a small gauze net up and down among the heads of grain, and therein retained for future examination.

* Occasionally they have been found as late as the middle of August.

What does he propose calling the insect? When did these insects first attract attention in this country? Where did they appear? How fast did they spread, and in what direction? Where are they to be found at present? At what time does the fly usually make its appearance? How long does it continue, and what does it do? At what time may it be most easily detected? When does it appear in great numbers? Where does it deposit its eggs? How may they be caught?

Soon after the insect makes its appearance, the female insinuates its long and pointed ovipositor within the chaff that incloses the blossom, and which of course must inclose the future berry or kernel, and deposits its minute ova, or eggs, generally from six to ten in number, and shortly after dies. The eggs are oblong, cylindrical, nearly colorless at first, but afterwards acquiring a yellowish tinge; and are hatched in little more than a week after they are deposited. When first hatched, the larva is a minute, oblong worm, nearly transparent, or of a whitish tinge, and without feet or hairs. As it increases in size it becomes an orange color, and moves slowly by means of a wriggling motion of its body. It seldom or never leaves the particular floret or germ where the egg was deposited until it attains its full size, which is about one month after hatching.

During the period of its growth, it clusters around the soft germ and lives on the juices which are destined to nourish it, thereby causing it to remain shriveled, imperfect and worthless. And such are the numbers of these minute worms, that they sometimes not only destroy the wheat in whole fields, but throughout entire sections of country many miles in extent.

Thus Mr. Gorrie tells us, that in the rich alluvial district along the Isla, in Perth and Forfarshire, (Scotland,) they destroyed wheat to the value of more than eighty thousand pounds sterling, during the years 1827, '8, '9; and between the years 1828

In what manner, and how many eggs does it usually deposit? What then becomes of the fly? Can you describe the eggs? How long before they are hatched? What is the appearance of the larva at first? What changes take place afterward? How long is it in attaining its full size? How does it injure the grain? How great is the destruction sometimes occasioned by these larvæ or worms? What was the loss estimated by Mr. Gorrie, of Scotland, in three years?

and 1834 its ravages were so destructive in Vermont and Washington county in this State, as to lead to an almost total abandonment of the cultivation of wheat in that extensive section of country for several years. For a few years past its ravages have not appeared so destructive in any one section of country, although it seems to be still annually spreading westward through New-York.

The worm attains its full size, which is nearly one-tenth of an inch, about the first of August, or a little before the wheat is ripe to harvest. It then remains dormant in the head, or falls to the ground, attaching itself to straws, sticks or stones on the surface, where it remains in the same state until the following spring. In this dormant state the pupa or worm remains of a rich orange color, and the same general appearance that we have already described. It is, however, harder and less movable, and, if minutely examined, will be found divided into twelve sections or segments of about equal length. Those that adhere to the heads of the wheat may be found, often in abundance, on the threshing-floor, or in the screenings of the fanning-mill. The pupa, chrysalis or dormant state of the worm continues until about the middle of the next June, when it again changes into the small fly which we have described.

Means of destroying the wheat fly, or preventing its ravages.—The wheat fly, like other species of the cecidomyia, has some natural enemies that aid the farmer very materially in his efforts to destroy it. Among these, perhaps, the yellow-bird is the most

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At what period were its ravages very great in Vermont and in Washington county in this State? To what did this destruction lead? What has been the character of its operations during the last few years? How large is the worm when of full size? In what places, and how long does it remain dormant? What is its color and other characteristics while in the dormant state? Where may they generally be found? When do they change into the fly state? Has the wheat fly or its larvæ any natural enemies?

important. This beautiful little bird is generally found in considerable numbers, almost constantly, in the wheat fields during the month of July, in those districts infested with this insect. It freely lights on the straw, just below the head, and, with admirable discrimination, pulls down with its bill the chaff that conceals the wheat worms, and picks them off, often leaving the berry unharmed. It is the operation of this bird that gives the wheat heads that rough and broken appearance which is often observed in fields infested with the wheat worm. There are also several parasitic insects that attack and destroy the larvæ of the wheat fly.

The artificial means of destroying this insect may be considered under two heads. First, its destruction while in the pupa or dormant state; and, second, the destruction of the fly before it deposits its larvæ or eggs in the wheat heads, and the protection of the wheat against its action. We have already said, that when the wheat worm had attained its full size it became dormant, and sometimes fell to the ground, becoming there attached to straw, sticks, &c., and sometimes it adhered to the wheat head until it was gathered with it into the barn. These latter will always be found, after threshing, among the screenings of the fanning-mill. Hence these should always be examined, and if there are any considerable number of these little yellow pupæ to be seen, the whole should be at once thrown on the fire and burned. But if their number is very small, they may be fed with the screenings to hogs or other

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Which is the most important of these? How does the yellow-bird destroy the larvæ? What other enemies attack and destroy these larvæ? How may the artificial means of destroying this insect be arranged? In what state is the insect when attacked by the first class of means? In what state when attacked by the second class? Where shall we find those larvæ or pupæ that remain in the wheat heads? How may these be destroyed?

animals; but in no case should they be thrown into the barn-yard, or any other place where they can rest secure among straw or grass until they assume the fly form in the spring.

The destruction of those that remain in the field, is a task of much greater difficulty. It has been proposed to burn over the stubble; and if this was done during a very dry time after harvest, it would doubtless destroy the greater part of them. Still, there would be many left under stones, and in moist places, where the fire would not reach them. However, if every farmer throughout an infested district would carefully destroy the screenings of his fanning-mill, and burn over his stubble for two or three years in succession, it would probably effectually destroy this dreaded enemy of the wheat-grower. It has also been suggested, that a thorough ploughing of the field in the autumn, after the wheat has been removed, would bury the pupæ so deep as to destroy them.

For destroying the fly before it deposits its eggs in the wheat head, or for protecting the wheat against its depredations, many ways have been suggested. Some have advocated the burning of sulphur around the field, in such a way that the smoke should be diffused among the grain; others have strongly recommended us to sow over the field, at the time it was in blossom, a few bushels of lime.

But experience has proved the inefficiency of both these projects. Thus, Dr. Fitch states, in an essay on this subject, published in the American Quarterly Journal of Agriculture, that the fly was seen to deposit her eggs as freely in a wheat head well

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What should never be done with them? How may those that remain in the field be destroyed? Is this a certain remedy? What are some of the means that have been proposed for destroying the fly before it deposits its eggs? What has experience taught in regard to both of these projects?

covered with recently burned lime, as in those on which no lime had been put. Indeed, we are confident that no application can be made directly to the grain, of sufficient strength to prevent the action of this insect, without proving, at the same time, destructive to the grain itself. Hence we know of no way more likely to prove effectual than the one suggested by Dr. Fitch, in the paper just alluded to.

This consists in preparing a fine gauze net, some six feet long and two feet deep, in such a way that the mouth will open two feet wide the whole length of the net. As soon as the fly appears about the wheat heads, two men should carry this net, by means of a cord, in such a position that the lower part of the open mouth shall fall a little below the heads of grain, and the other considerably above them. It should be carried in this position back and forth at a quick pace over the entire field. Whenever a halt is made, the mouth of the net should be instantly closed, and the two sides pressed together sufficiently firm to crush whatever insects had been gathered in. No doubt but two or three repetitions of this during the period that the insect is depositing its egg, would entangle millions on millions of the little depredators, and perhaps destroy the greater share of them before any considerable mischief could be done. We hope this suggestion will be acted on extensively during the coming season, as soon as the fly begins to appear, that its precise value may be ascertained.

Why cannot any substance of sufficient strength to kill the fly be applied directly to the wheat? What is the method proposed by Dr. Fitch? In what position should the net be held? Should it be carried fast or slow? What should be done whenever a halt is made with the net? How many times should this process be repeated during the season, in order to give it a fair trial?

CECIDOMYIA DESTRUCTOR.*

The Hessian fly, or Cecidomyia Destructor of Say, first made its appearance in this country in those districts which had been occupied by the Hessian or German soldiers during the Revolutionary War. Hence the name Hessian fly. It belongs to the same class with the Cecidomyia Tritici, from which it differs principally in being of a dark-brown or black color, instead of yellow.

It makes its appearance in the month of May, or early in June, and deposits its eggs on the leaf of the wheat stalk. As soon as the eggs hatch, the minute young larvæ, or worms, crawl down to the stalk, and become burrowed around the tender stem just above the first joint, where they present nearly the size and appearance of a flax-seed, with the head always downward towards the roots of the stem. They do not eat the stem, but suck out its juices to such an extent as to cause it to first turn yellow, and afterwards die. Hence, unless the farmer is constantly on the look-out, the first intimation he will have of the ravages of this insect, will be the yellow and shriveled appearance of his wheat about the time the heads begin to appear.

After the larvæ attain their full size, they remain dormant until October, when they again assume the

* See Plate II.

What is the proper name of the Hessian fly? When did it make its first appearance in this country? Why is it called Hessian fly? To what class does it belong? In what respect does it differ in appearance from the Cecidomyia Tritici? When does it make its appearance? Where does it deposit its eggs? What becomes of the larvæ when the eggs hatch? What is the appearance of these larvæ? What part of the wheat plant do they attack? What position do they always occupy? How do they injure the wheat? What is the first appearance of injury in the wheat? What becomes of the larvæ after they attain their full size? How long do they remain dormant?

Fig. 1. Female of the Cecidomyia Destructor or Hessian fly, much magnified.

Fig. 2. Male fly of the Cecidomyia Destructor, also much magnified.

Fig. 3. A stalk of wheat with three pupæ or worms of the Hessian fly at *n*, just above the first joint.

Fig. 4. Pupa or worm of the Hessian fly, considerably magnified.

active fly form, and immediately deposit their eggs on the leaves of the early September sown winter wheat. These again become dormant during the winter, to make their appearance in the fly state the following May or June. Thus we have two generations of this insect in one year; the first committing its depredations principally on spring wheat, or that sown late in autumn; while the last is equally destructive on that sown early in autumn.

Means of Destroying the Hessian Fly.—The remarks which we have made in regard to the destruction of the Tritici are equally applicable to this. It is very probable, however, that sowing the field over with lime or ash, or both combined, about the time the insect appears, would have more effect in preventing injury from this fly than the other, on account of the much more open and exposed situation of the eggs on the leaf. For the same reason, a much larger number of these eggs and larvæ are destroyed by birds and parasitic insects.

Something will also depend on the soil and the kind of wheat cultivated; for the more vigorous the growth of the stem, and the more firm and hardy the kind of wheat, the less will be the impression of these worms upon it. Hence a proper preparation of the seed, and a judicious manuring of the soil, so as to give the wheat a quick and vigorous growth, is of no small importance with a view to avoid this

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When they have assumed the fly form where does this generation deposit its eggs? During what season do these again remain dormant? How many generations of this insect do we have in one year? Do our means of destroying this fly differ from those applicable to the Cecidomyia Tritici? Why will the application of lime, ash, &c., have more effect on the larvæ of this insect than those of the C. Tritici? What varieties of wheat and what kinds of soil are least apt to be injured by the C. Destructor? What then should be done to the seed and the soil before sowing?

insect. The destruction which is sometimes occasioned by the Hessian fly, is only equaled by that of its neighbor, the Tritici.

CALANDRA GRANARIA.*

The Wheat Weevil, Calandra Granaria, or Curculio Granaria of Linneus, is a small bug or beetle, of a dark-red color, furrowed wing-covers, punctured or spotted thorax, and long slender snout, with two minute antennæ or feelers near its end. It does all its mischief to the wheat after it is threshed and stored in the granary, by eating into and destroying the berry, in the same manner as the well-known pea bug. This insect, or beetle, is confined almost exclusively to the Southern States of the Union, where it often proves very troublesome and injurious.

It may be entirely destroyed, however, and all its mischief prevented, by kiln-drying the wheat at a temperature of 104° for two days, or at a higher temperature for a shorter time, before it is stored away after threshing; and afterwards keeping it well ventilated and occasionally stirred. This troublesome little insect may be conveniently destroyed in seed wheat, by soaking it eight or ten hours in a solution of common salt or muriate of ammonia, then rolling it in lime, drying and sowing.

* See Plate III, Fig. 2.

Is the injury done by the Hessian fly often very great? What is the proper name of the wheat weevil? What is the appearance of the Calandra Granaria? When does it injure the wheat? How does it attack the wheat? To what sections of the country is this insect confined? Does it ever do much injury? How may it be entirely destroyed? At what temperature, and how long should the wheat be dried? What is necessary after the wheat is stored away? How may the bug or insect be destroyed in the seed wheat before sowing?

There are two other insects which feed on grain to such an extent as occasionally to become troublesome. These are moths, which deposit their eggs on the berry of the grain, whether it be wheat, rye, oats or barley. The first of these is called the Tinea Granella; and its eggs, when hatched, present a small, soft, naked caterpillar, with sixteen legs. It is of a light buff color, with a red head, and about five-tenths of an inch long.

The second is the *Alucita Cereabella* or Angoumois moth. It usually deposits its eggs in the heads of grain before harvesting. When hatched the minute worms or larvæ penetrate the berry, feed on it until it attains its full size, and then remain dormant in its cavity until they change again into the moth. Both these insects, and their larvæ or worms, may be effectually destroyed in the same manner as the wheat weevil.

PHALÆNA NOCTUA DEVASTATOR, OR CUT-WORM.

This worm is the product of a moth, which probably deposits its eggs in the latter part of summer, or early in the autumn, and the young larvæ or worms enter into the ground, where they remain during the winter, ready to commit their depredations in the spring. The worm, as it appears in the corn field or garden, is of a grayish-brown color, of a thick sluggish appearance, and from half an inch to an inch in length. It remains buried in the

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Are there any other insects injurious to the different kinds of grain? Where do these deposit their eggs? What are these insects called? What is the appearance of the larvæ of the Tinea Granella? How do the larvæ of the Alucita Cereabella injure the grain? How may both these insects and their larvæ be destroyed? What is the name of the cut-worm? Of what is it the product? When does the moth probably deposit her eggs? When does the worm do most of its mischief? What is the size and general appearance of the worm?

ground during the day, but comes to the surface at night and feeds on the young corn, beans, cabbage, turnips, &c.; cutting off the stalks even with the surface of the ground, and often dragging the tops into the dirt after them.

These worms sometimes exist in such numbers as to do great mischief both in the corn-field and the garden. The only sure way to destroy them is to dig them out of the hills as soon as they commence their work, and kill them. This not only destroys the worms, but of course prevents them from changing into the moth state, and thus puts an end to the generation. Placing a little salt or lime and ash in each hill, will serve to prevent their depredations in a great measure.

It has also been thought by some, that soaking the seeds in saline solutions before planting would serve as a preventive. Our own experience, however, leads us to think this opinion fallacious. If it is true that the eggs are hatched in the autumn, and the larvæ or worms enter the ground, ploughing about the time severe frosts commence would probably cause many of them to be destroyed. Accordingly we find such fields as have been ploughed late in the fall less liable to injury from these worms than those not ploughed till spring.

GORTYNA ZEA, OR SPINDLE WORM OF CORN.

The spindle worm is the larva of a moth called

What are its habits? What crops does it principally attack? Does it ever do much injury? What is the only sure way of destroying them? Does this mode only destroy the worm itself? What substances placed in the corn-hill will act as a preventive to some extent? What effect is produced by soaking the seed in saline solutions before planting? What effect would be produced by ploughing the ground about the time the severe frosts commence in autumn? Why would this destroy the worm? What is the parent moth of the spindle worm called?

Gortyna Zea, by Harris. Its injurious operations are confined principally to Indian corn, the stalk of which it attacks above the lower joint, just before the head or *tassel* begins to protrude above the large leaves that surround it. The worm perforates the stalk, sometimes almost cutting it off, and always causing it to wither and die.

Its existence may be readily detected by the withered appearance of the upper and central leaves, and the perforations in the stem. On pulling open the stem, the worm will generally be found in its centre, nearly an inch in length, smooth, shining, of a yellowish brown color, head nearly black, and, when fully grown, nearly as large round as a small goose quill. It moves with considerable activity when touched. There is no known remedy but to pull up the first stems affected, and burn or destroy them, thus preventing the worm from entering the moth or fly state.

It is probable, also, that the eggs from which this worm proceeds are first deposited on the leaves, much in the same manner as the eggs of the Hessian fly on the wheat leaf. Hence it is very probable that if the exact time in which the moth appeared to deposit its eggs was known, some better mode of preventing the effects of the worm might be devised, by destroying the eggs before they were hatched.

ELATOR LINEATUS, OR WIRE-WORM.

The Elator Lineatus is the moth, or perfect insect

To what crop is its operations mostly confined? When and where does it attack the corn? How may its existence be detected? How and where will you find the worm? What is its size and appearance? What is the only known remedy? Where are the eggs of the Gortyna Zea probably deposited? at might be done if the exact time of their being deposited known? What is the name of the parent moth of the wire-?

from whose eggs the wire-worm is produced. The worm itself may be readily distinguished by its deep brownish yellow color, with two dark spots on the last segment of its body. This worm sometimes attacks potatoes, turnips and other root crops, both in the garden and the field. But its principal ravages are in the corn field. It penetrates the stalk just below the surface of the ground, where sometimes half a dozen may be found at one time, with half or two-thirds of their length buried in the same stalk.

They are much more apt to be found in those grass lands which have been turned over in the spring and planted on the sward, than in those ploughed in the fall. Hence we infer, that the eggs are deposited early in autumn, and that the young larvæ or worms penetrate beneath the surface to avoid the frosts of winter. Consequently, thorough ploughing, late in the fall, by dislodging them from their places of retreat, causes far the greater share to be destroyed by the cold. Indeed, thorough fall ploughing is the most effectual remedy yet known to avoid the ravages of this worm. A spoonful of common salt in each hill of corn or potatoes, would doubtless destroy the wire-worm in a great measure; but the difficulty with this is, to so regulate its application that it will not destroy the crop as well as the worm.

GALERUCA VITTATA, OR STRIPED CUCUMBER BUG.

This common and well-known pest of the

How may the worm itself be distinguished? What crops does this worm attack? On what does it commit the greatest depredations? What part of the corn stalk do they attack? In what fields are they most apt to be found? When are the eggs probably deposited? Where do the larvæ or worms remain during the winter? What is the most effectual remedy? Why? What may be applied in the corn hill to destroy or prevent the action of this worm? What danger is there in doing this? What is the name of the striped cucumber bug?

gardener generally makes its appearance suddenly, soon after the cucumbers, melons, squashes, pumpkins, &c., put forth their first leaves in the spring; and such are their numbers, that if not destroyed by the vigilant hand of the husbandman, they in a few days destroy almost every vestige of the first leaves on these vines. The young plants in consequence droop and die.

The *yellow-striped bug* is too well known to need a particular description here. An almost countless number of remedies have been recommended as infallible safeguards against the ravages of this little animal. Prominent among these stand lime, plaster, ash, soot, snuff, and infusions of tobacco, Cayenne pepper, &c. But they have all been tried again and again without success. Surrounding the hills with small square boxes has been found more effectual, particularly when covered with millinet. But there is no remedy so certain and so cheap as the faithful application of the *thumb* and *finger* every morning, for a few successive days.

HALTICA PUBESCENS, OR CUCUMBER FLEA.

There are several varieties of the Haltica, of which the H. Pubescens and H. Striolata are the most important. The first, like the striped bug or beetle, attacks the cucumber and other vines as soon as they are up; while the latter is equally destructive to the young cabbage, turnip, radish, and

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How and when does it make its appearance? What plants do they attack, and to what extent do they commit injury? What is their color? What are some of the principal remedies that have been proposed for protecting plants against its ravages? Can any of them be relied on? What has been found more effectual? What is a certain remedy when faithfully applied? Which are the two most important varieties of the Haltica? What does the Haltica Pubescens attack? What does the Haltica Striolata destroy?

other similar plants. It is a small black bug, or beetle, named Haltica from its leaping habits.

The best mode of avoiding injury from these insects, is to sprinkle the young plants daily with a mixture of one part of urine with three parts of some intensely bitter infusion—such as the infusion or decoction of tansy, wormwood, &c. The effect of such a mixture is two-fold. The bitter water renders the tender plants offensive to the insects, while the urine greatly increases the rapidity of their growth, and consequently soon brings them beyond their reach.

APHIDES, OR PLANT LICE.

The Aphides are a numerous and exceedingly curious race of insects. They present many varieties, of which those infesting turnips, cabbages, radishes, &c., and the Aphis Lanata, or apple-tree louse, are the most important. The plant louse is a small whitish-green insect, which fixes itself either on the under side of the leaf, or on the bark of the stem or branches of trees; and generally remains in one position through life. It is almost always found congregated together in immense numbers, and it multiplies with astonishing rapidity; so much so, that a single Aphis, or louse, may be the parent of millions in one season.

They have no mouth, and maintain their existence by sucking the juice of the plant to which they are

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What is the appearance of this insect, and why is it called Haltica? What is the best mode of avoiding injury from these insects? What are the effects of such a mixture? What are Aphides? What do the Aphides present? Which are the most important varieties? What is generally the appearance of the Aphis or plant-louse? Where does it fix itself? How are they generally found? How rapidly do they multiply? How do they maintain their existence?

fixed; and those varieties which fasten themselves to the leaves, convert the juice into a sweet honey-like substance, which sometimes falls to the ground in considerable quantities, attracting great numbers of ants, flies, wasps, &c., to feed on it. It is undoubtedly this product of the Aphis which some have called honey-dew, and to which they have ascribed qualities injurious to vegetation. They often cover themselves with a whitish mealy substance, which gives them a peculiar appearance.

The Aphis Lanata is distinguished by its attaching itself to the bark of the apple, willow, and some other trees. It is easily and completely destroyed by the free application of white-wash, or a few washings with strong soap-suds. The other varieties are not so easily destroyed, on account of their situation on the under side of the leaf, and the tenderest parts of the stem. Perhaps the surest mode of preventing their injurious effects, is to watch closely and pluck off and destroy the first colony that appears, and thereby prevent their increase. The many washes, such as soap-suds, tobacco-juice, hot water, &c., which have been reported as remedies, are at least of doubtful efficacy, if for no other reason than the almost impossibility of applying them directly to the vermin.

The Coccus Arboreum Lineatus of Geoffry is only another species of bark louse, and is found in immense numbers on the bark of young apple trees.

When fastened on the leaves, what effect do they produce on the juice of the plant? What is honey-dew? With what does the Aphis often cover itself? How is the Aphis Lanata distinguished? How may it be easily destroyed? Why are not the other varieties as easily destroyed? What is the best mode of destroying them? Why are not the many washes, &c., that have been proposed, effectual? What other species of bark louse is there?

It is effectually destroyed in the same way as the Aphis Lanata.

CLISIOCAMPA AMERICANA, OR APPLE TREE CATERPILLAR.

This very troublesome animal is too well known to every one who has observed an orchard in the spring and early part of summer, to need a particular description here. The eggs from which the worms are derived are generally deposited on the branches of apple or cherry trees, and hatch about the time the leaves begin to appear in the spring. They soon weave for themselves a large white net-work or web, into which they congregate in immense numbers. They feed on the young leaves, and such are their numbers and voracity, that they sometimes strip an entire tree of its foliage in a few weeks. Indeed, during the last few years this caterpillar has multiplied to such an extent as to completely destroy the leaves and blossoms (and of course the fruit) of whole orchards.

But such a result can only be effected by the culpable negligence of the owner; for, as in all other cases, many remedies have been proposed, yet there is *one*, and only one, infallible remedy, viz: a ladder and a good firm pair of mittens, with fearless and faithful hands in them. Thus equipped, as soon as all the eggs are hatched and the web or nest is so conspicuous as not to be overlooked, they should be seized in mass, and with one grasp of the hands

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How may it be destroyed? What is the name of the apple tree caterpillar? Where are its eggs usually deposited, and when? What do the young worms or larvæ do first? On what do they feed, and to what extent? What has it effected within a few years? What is the only effectual and certain remedy? How should they be destroyed?

crushed to death. This not only effectually saves the orchard for the present year, but it prevents a succeeding generation, and therefore protects, in a great measure, for the year to come.

PHALÆNA VERNATA, OR CANKER WORM.

The Phalæna Vernata is the parent moth of the canker worm, sometimes called surveyor, loper caterpillar, or inch worm, from its manner of traveling. The moths generally make their appearance in March, or as early as the warmth of spring commences. The male is possessed of perfect wings, and flies with ease; but the female has only the rudiments of wings, and moves only by crawling. As soon as they appear, they hasten to the nearest fruit tree, which they ascend, generally to the extremities of the topmost branches, and then glue their eggs to the fruit buds or small twigs, and soon die. The same degree of warmth that causes the buds and blossoms to open, causes these eggs to hatch; and neither rain nor cold will destroy their vitality.

The young worms are scarcely larger than a hair, and nearly transparent. They feed on the delicate leaves, blossoms, and young fruit—their voracity increasing with their size. When very numerous, they protect themselves by a small web or net, much less conspicuous, however, than the nest of the apple tree caterpillar. Their period of growth continues

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What does this prevent? What is the parent moth of the canker worm? What other names has this worm? When do the moths appear? What is the difference between the male and the female? Where and in what manner do they deposit their eggs? What causes the eggs to hatch? Are they affected by cold or wet? What is the appearance of the young larvæ or worms? On what do they feed? In what respect do they resemble the Clisiocampa Americana?

about four weeks, at the end of which time they forsake the tree, sometimes letting themselves down by a minute thread, like the spider, at others falling or crawling down to the earth. The worm now penetrates the earth two or three inches, where they remain dormant, or in the chrysalis state, until the next spring, when they again make their way to the surface in the shape of the perfect moth. If, however, accidental causes should bring the dormant worm to the surface, where it would be exposed to the full heat of summer, it undergoes its transformation into the moth state in the autumn instead of spring.

The ravages of this worm have been hitherto confined chiefly to the Atlantic States; and in some sections of these it has committed great depredations. Fortunately it has many enemies; for the eggs are attacked by one or two species of flies, the worms are picked from the trees by birds, and a large ground beetle feeds on them in the dormant state. These, together with the absence of perfect wings on the female moth, effectually prevent it from spreading, at least with any considerable rapidity.

As the female moth can ascend the tree to deposit her eggs only by crawling up the trunk, many plans have been devised for preventing her ascent, one of which has been patented by Mr. Dennis, of Rhode Island. Perhaps the cheapest and most effectual mode yet devised, is to surround the trunk of the tree with a wooden box six inches deep. The box

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How long do they continue to grow, and how do they leave the tree? Where and how long do they remain dormant? Under what circumstances does it undergo its transformations sooner? To what sections of the country have the ravages of this insect been confined? By what other animals are they destroyed? How does the female moth ascend the tree? Can you describe the cheapest and most effectual mode of counteracting the depredations of this insect?

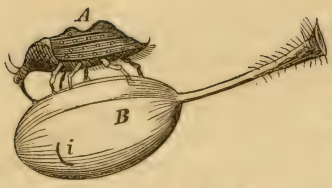

Fig. 1. A. Rhynchænus Nenuphar, or plum weevil, about three times its natural size.
B. Plum also magnified.
i. Semicircular incision made by the weevil.

Fig. 2. A. Calandra Granaria, much magnified.
B. The weevil of its natural size.

Fig. 3. Saperda Bivittata, or apple-tree borer.

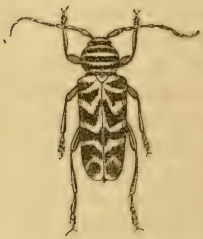

Fig. 4. Clytus Pictus, or locust borer.

is made by simply nailing four pieces of board together, with their lower edges firmly imbedded in the earth, and on the top a strip two or three inches wide, nailed in such a manner as to form a kind of cap or shelf outwardly. The whole outside of the box and under side of the projecting cap should be kept well smeared with tar, cart-grease, or anything of an offensive and oily nature. The female moth cannot well get over this kind of box or cap, and hence all the ravages of the worm on the tree are prevented.

SAPERDA BIVITTATA, OR APPLE-TREE BORER.*

The Saperda Bivittata is an insect with the head vertical and as broad as the chest; body cylindrical; inferior lip straight; antennæ filiform, terminating in an elongated joint. The upper side of the body is marked with two white longitudinal stripes, between three of a light-brown color; face, antennæ, under side of the body, and legs, all white.

It makes its appearance early in June, and soon deposits its eggs on the bark of the tree, near its roots. In seven or eight days these hatch into a round, white grub or maggot, without any appearance of legs. It soon eats its way through the bark, beneath which it burrows the first winter; and during the two following years it cuts its way into the sap-wood, taking an upward direction, sometimes to the depth of several inches. About the

* See Plate III., Fig. 3.

What should be applied to the outside of the box? What is the parent of the apple-tree borer? Describe the insect. At what season does it appear, and where does it deposit its eggs? How long before these hatch? What does the worm do the first year? What is its course the second and third year?

third or fourth year it becomes transformed into the insect which we have described, and comes out to seek its mate and deposit its eggs.

So numerous are these grubs or worms, that they sometimes entirely destroy the life of the tree; and are at all times injurious to its health and growth. Three or four modes have been recommended for destroying this worm; such as plugging up the hole with soft wood; injecting into it liquids calculated to destroy the worm, such as strong lye, solution of corrosive sublimate, &c.; cutting them out with a chisel or knife; or killing them by thrusting a wire into their holes. Of all these methods, the latter is undoubtedly the safest and best; but it will be observed that none of these methods attack the worm until it has done at least a part of its mischief.

Mr. Buckminster's method of washing the trunk of the tree, especially near the ground, every year about the time the eggs are hatched, is, in our opinion, a much better and easier method. Two or three washings with strong lye, during the last half of June and the first of July, would doubtless completely destroy the eggs and avoid all injury. Of course all suckers or sprouts should be kept from the roots. This worm often attacks the quince, mountain ash, and hawthorn, as well as the apple tree.

CARPOCAPSA POMONELLA, OR APPLE WORM.

The Carpocapsa Pomonella, known as the codling

What change does it undergo during the third or fourth year? What effect do they have on the apple tree? What modes of destroying this worm have been suggested? Which is the safest and best? What objection rests against them all? Who has proposed a much better method, and what is it? When and how often should the washings be applied? What other trees besides the apple tree does this worm attack? What is the name of the parent moth of the apple worm?

or fruit moth, appears about the first of July, and, without puncturing the apple, it deposits its eggs in the hollow at the blossom end. In a few days the eggs hatch, and the young worms commence penetrating into the apple directly towards the core, leaving a small hole from which its chips and excretions are thrown out. In about three weeks the worm has penetrated to the core of the apple, and attains its full size about the first of August. They often cut a hole directly through the side of the apple also, to enable them the more easily to keep their burrow clear.

Sometimes the worm leaves the apple before it falls; but generally the injury which the apple has received causes it to fall prematurely, when the worm leaves it, incloses itself in a cocoon, remains dormant or in a chrysalis state a few days, and again comes out a moth or perfect insect, to renew its depredations on another set of apples. This second crop remain in the fruit when gathered, and do not undergo their change into the moth or insect until the following spring.

In some seasons, especially in New-England, the whole apple crop has been greatly injured by this insect; and I have now a choice tree on my premises, the apples on which, the last year, were rendered almost entirely worthless by it.

The only mode of destroying the apple worm which can be relied on, is to shake the tree well about the first of August, that all the apples already

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At what time does it appear, and where does it deposit its eggs? How long before the eggs hatch, and what is the course of the young worms? When does it attain its full size? What changes does it then undergo? How long does it remain dormant? What becomes of the second class? When do they change into the moth again? To what extent is the apple crop sometimes injured by this worm? What is the only reliable mode of destroying this worm? At what time should this be done?

injured may fall off, and then carefully gather them up and destroy them, by feeding to hogs or otherwise. Some recommend letting swine run in the orchard for this purpose.

SCOLYTUS PYRI, OR PEAR BLIGHT.

This is a beetle of a dark-brown color, about one-tenth of an inch in length, which deposits an egg near the root of the bud. The egg hatches into a small worm, which penetrates towards the centre of the branch, and burrows around the pith, cutting off a great part of the circulation of sap, and causing the branch to wither and die. This is repeated until the whole tree becomes dead. It is but a few years since, that many fine pear trees were entirely lost by this beetle and worm. But this may be entirely prevented by simply removing every branch as soon as it begins to appear withered, and burning it to ash.

RHYNCHÆNUS NENUPHAR, OR PLUM WEEVIL.*

This is a beetle of a dark-brown color, one-fifth of an inch in length, with a long curved snout, which it uses for puncturing the fruit. The punctures are made in a semicircular form, and in each one or more eggs are deposited, which hatch into a small white grub or worm. This feeds on the pulp and juices of the green fruit, causing it to become

* See Plate III., Fig. 1.

Describe the Scolytus Pyri. Where does it deposit its eggs? How do the worms injure the tree? What trees do they mostly injure? How may they be prevented? What is the name of the plum weevil? Describe the Rhynchænus Nenuphar. How and where does this insect attack the plum? What is the appearance of the young larvæ or worms?

gummy, and often withered. When the worm has arrived at maturity, it leaves the fruit and enters the ground, where it remains three or four weeks, and again appears in the form of a beetle, or perfect insect.

This insect not only attacks plums, cherries, peaches, &c., but its grub or worm penetrates the branches also, causing them first to become filled with black, mossy looking spots, and ultimately to die. Indeed, so destructive has this insect been to the plum and cherry trees in some places, that their culture is well nigh abandoned.

The only effectual mode of destroying or preventing its effects, is to carefully gather up and cause to be consumed, either by fowls, hogs, or fire, all the early fallen and withered fruit, and also every twig, as soon as a black spot appears on it. To accomplish this more effectually, blankets should be spread under the trees and they shook violently. If this is done soon after the trees are in blossom, very many of the insects will fall on the blankets and may be destroyed. And if it is repeated again in four or five weeks, most of the affected fruit will fall with the worms in it, and may also be destroyed. (?) If this process is repeated two or three times at each of these periods, the injurious effects of this destructive little animal will be almost entirely prevented. It is true, that this remedy requires vigilance on the part of the fruit-grower; and so does everything else worth accomplishing.

On what does it feed, and what are its effects? Where and how long does it remain dormant? What kinds of fruit does this insect attack? Are its injurious effects confined to the fruit alone? What is the appearance of the branches, and how far do its injurious effects sometimes extend? What is the principal remedy? How can it be most effectually accomplished?

ÆGIRA EXITIOSA, OR PEACH BORER.

This wasp-like moth generally makes its appearance in July, and deposits its eggs on the peach tree, near its roots, in the same manner as the Saperda Bivittata, or apple-tree borer. Indeed, the habits of this moth, and the grub or worm which results from it, in regard to the peach tree, so closely resemble the influence of the latter on the apple tree, that we need not repeat the description. The peach borer sometimes, however, penetrates the trunk of the tree higher up than the Saperda. Mixing salt, ash, or lime, with the earth around the tree, and two or three washings of the trunk with lye during the month of July and first of August, are the best remedies.

CLYTUS PICTUS, OR LOCUST BORER.*

This pest of the locust tree makes its appearance in September. Its body is black, with numerous ziz-zag streaks of yellow running across it; tips of the wings edged with yellow; and legs of a dull red. Soon after their appearance they deposit their eggs in the crevices or depressions of the bark of the locust. These soon hatch, presenting a small white grub, which immediately penetrates the bark, beneath which they remain torpid during the first winter. In the spring they penetrate the wood, in winding passages, which give rise to swellings in the tree or limbs, and greatly impair its nourishment.

* See Plate III., Fig. 4.

What is the Ægira Exitiosa? In what respect does it resemble the Saperda Bivittata? What are the best remedies, and when should they be applied? When does the Clytus Pictus make its appearance? What tree does it attack? Describe the moth and also its larva or worm? Where and how do they attack and injure the tree?

The grub attains its full size about the middle of July, and leave the tree in the form of beetles or insects, in September. The principal means employed to destroy the Clytus, is to gather them off from the tree when they first make their appearance in September. Mr. Harris thinks that an hour a day devoted to this business, for a few days in succession, would clear the tree of them entirely.

CURRANT-BUSH WORM.

For several years we have noticed, about the last of July or first of August, the appearance of a small green worm of a caterpillar form, but possessing the soft and glairy appearance of the snail, on the leaves of currant and gooseberry bushes; and the same, or one very nearly identical, on the cherry tree. If unchecked in their progress, they speedily become so numerous as to strip the bushes entirely of their foliage, and cause the cherry-tree leaves to look as though they had been severely burned.

The late Mr. Gaylord recommended sprinkling the bushes with an infusion of Cayenne pepper; but a cheaper method, which we have found by three or four years' experience to be entirely successful, is to sow the bushes or trees over freely with dry, unleached ash, three times within the first ten days after the worm shows itself. The ash or ashes should be applied while the bushes are wet with dew or rain.

When do the grubs attain their full size? What is the principal mode of destroying them? What kind of a worm sometimes attacks the currant and gooseberry bush, &c.? What effects do they produce? What was recommended by the late Mr. Gaylord? What constitutes a cheaper and equally effectual method of arresting their progress? At what time and how often should the ash be applied? In what condition should the bushes be?

There are many other insects and worms more or less injurious to vegetation, which we might allude to did our limits permit; but enough has been written to impress the reader with the importance of this branch of study. And if it but awakens in the mind an interest in the subject, and thereby induces a more general study of Entomology by our agriculturists, we shall feel abundantly paid for our labor. For more extended works on the subject of this chapter, we take pleasure in referring the reader to the works of Harris, Gaylord, and the interesting articles of Dr. Asa Fitch, in the American Quarterly Journal of Agriculture and Science.

CHAPTER II.

ARTIFICIAL MANURES.

Recently much has been said about Guano as a manure, and much has been imported into various countries and purchased at a very high price. When properly prepared and applied, it is doubtless of great value in promoting the growth of crops. However, its price is not only too high for general use, but its supply will soon be exhausted. This is the less to be regretted, as we have no doubt but every farmer and gardener can make for himself, at much less expense, a manure of equal value.

Are there any other insects and worms injurious to vegetation besides those already described? To what interesting works may the reader refer with great profit? What has recently attracted much attention as a manure? What will prevent guano from being extensively used? Why is this to be but little regretted?

For instance, if we mix the following substances in the proportions stated, viz:—

Phosphate of lime, (burnt bones,)	15 pounds.
Carbonate of Ammonia,	10 "
Phosphate of Soda,	10 "
Sulphate of Magnesia,	6 "
Muriate of Ammonia,	5 "
Sulphate of Soda,	3 "
Sulphate of Potash,	5 "
Nitrate of Potash,	7 "
Humate of Potash,	20 "
Apocrenate of Ammonia,	10 "
Oxide of Manganese,	5 "
Bog Iron Ore,	2 "

they form a compound which may be used in all respects like the natural Guano, and with equal if not greater benefit. All the materials may be procured at any drug store, except the Humate of Potash and Apocrenate of Ammonia, both of which any farmer can make for himself: the first by melting saw-dust with a strong solution of caustic potash or strong lye, in an iron kettle; and the second by saturating swamp muck with a solution of Carbonate of Ammonia.

Every 100 pounds of this Artificial Guano, as the mixture has been called, need not cost more than $3 50. For use, it should be mixed with four or five times its weight of good earth. And of this mixture, from 500 to 1,500 pounds may be applied to the acre of either grain or grass land. For grain crops, it may be sown broad-cast, like plaster, and

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What substances may be so mixed as to form a good imitation of, and substitute for guano? How may the humate of potash be made? How the apocrenate of ammonia? What is the cost per 100 lbs. of this artificial mixture? With what should it be mixed for use? How much may be applied to the acre? How should it be applied to grain crops?

harrowed in with the seed; for corn, it may be applied in the hill.

If sown on meadows, or old grass lands, it should be done in wet weather, and it will be still better to drag the ground immediately afterwards. For use in the liquid form, as is sometimes desirable in gardens, one pound of the Guano, unmixed with earth, may be dissolved in four gallons of water, and applied in small quantities at a time, around the roots of plants.

After all that has been said through the Agricultural Journals in this country and in Europe about Artificial Manures, we must still contend that not only every farmer, but also every man who has a garden and a family, has all the materials for a full supply of manure, more enriching and better adapted to his wants than all the costly Guano or artificial mixtures that can be either imported from abroad or contrived at home; and that, too, with no other direct expenditure of money than the cost of a half dozen bushels of lime or plaster annually.

How the farmer, with his barn and farm stock, may do this, we have already described in another part of this work. But there are thousands in villages and cities who have gardens, but no stables from which to supply them with manure. If all such persons would, in some convenient corner of the garden or premises, prepare a tank, or large square box, and throw into it all the weeds, grass, or other waste vegetable matter to be found during the season in the yard and garden, with frequent layers of ash from their own hearths or stoves, and occasionally one of lime or plaster, together with all

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How should it be applied to corn? At what time should it be sown on meadows? How may it be used in the liquid form? How may the gardener obtain a quantity of good manure sufficient for his wants?

the bones and gleanings of the kitchen, all the soap-suds that is usually thrown away, and the urine that is emptied from vessels kept in the house, they would accumulate every year an ample supply for the garden of the very best quality of manure.

It might be objected by some, that such a heap of decaying and fermenting materials would be offensive and unwholesome; but the ash and plaster distributed through it effectually prevent this, by absorbing all the offensive gases as fast as they are formed. The heap should, of course, be sheltered so as to prevent its soluble and most enriching parts from being washed away by rains.

What prevents such a heap from becoming offensive? Why should it be sheltered from rain?

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